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Regeneration of Palladium Based Catalyst for Methane Abatement

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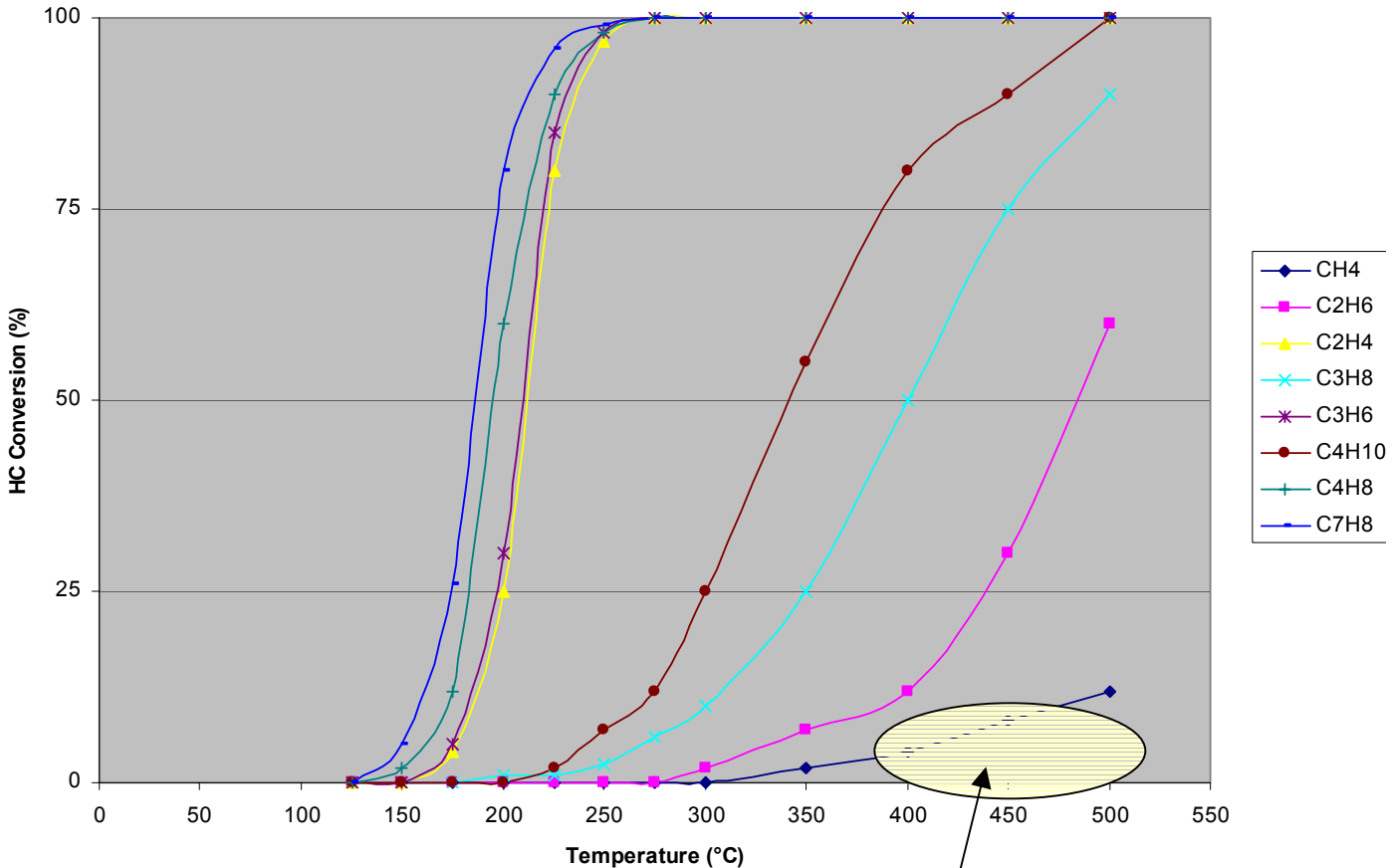
- **Introduction**
- Deactivation mechanisms
- Regeneration strategies
- Conclusion

Introduction

- Methane is a green house gas [$1 \text{ t}_{\text{CH}_4} \sim 20 \text{ t}_{\text{CO}_2}$]
- A 4 MW lean burn engine emits up to 300 tonnes of methane per year, or 6000 tonnes of CO₂
- If we were able to oxidize this methane with a catalyst, we could generate a € 30,000 credit
- Furthermore, in case of co-generation application, heat resulting for methane slip oxidation will be recovered in the exhaust, thus improving overall system efficiency
- Problem: methane is most stable hydrocarbon, therefore most difficult to oxidize with a catalyst
- How can we get 90% CH₄ conversion?

CH₄ Oxidation with Platinum catalyst

(Pt Alumina Catalyst SAE930735)

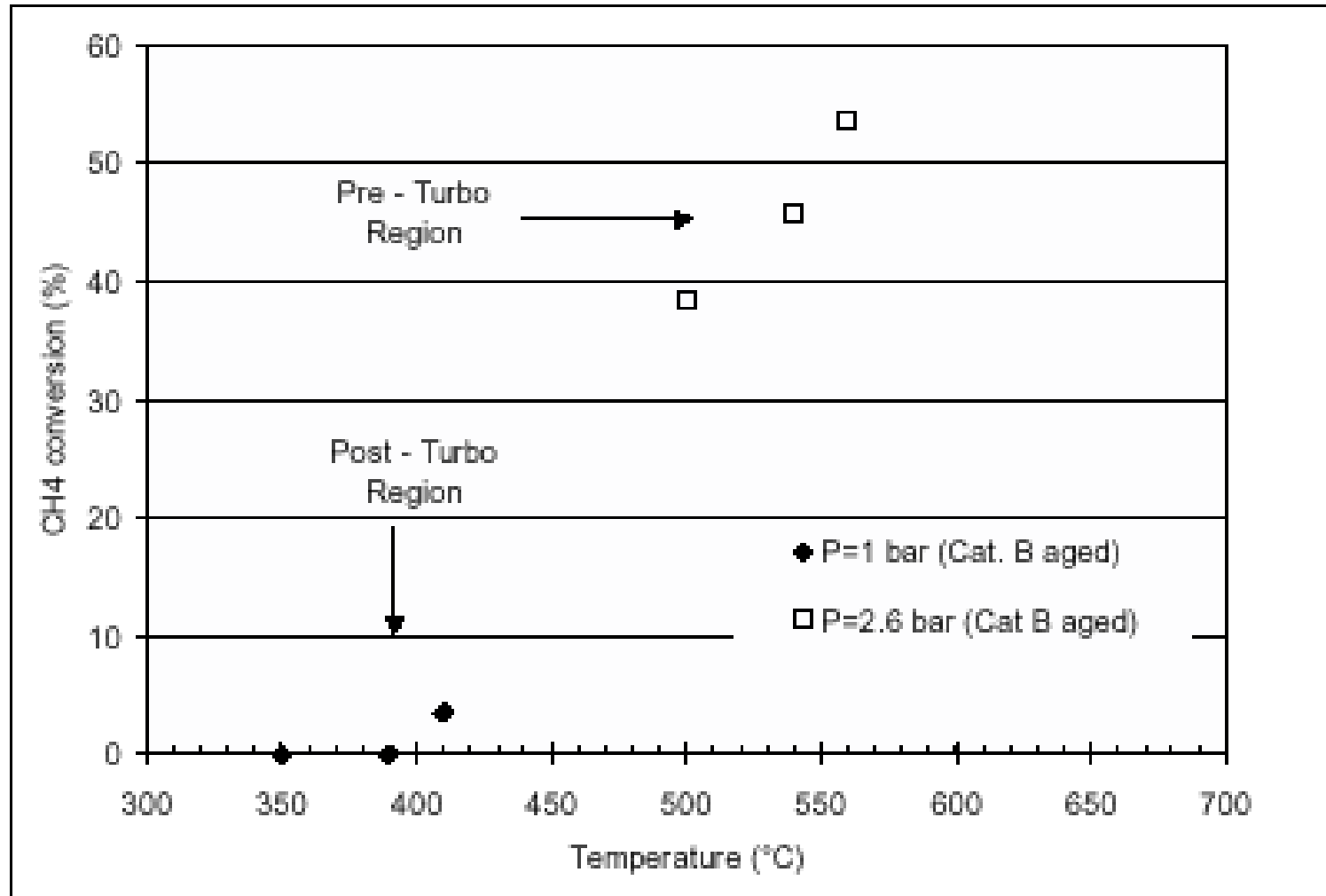


Operating window yields to little conversion

Need to install catalyst upstream of turbo

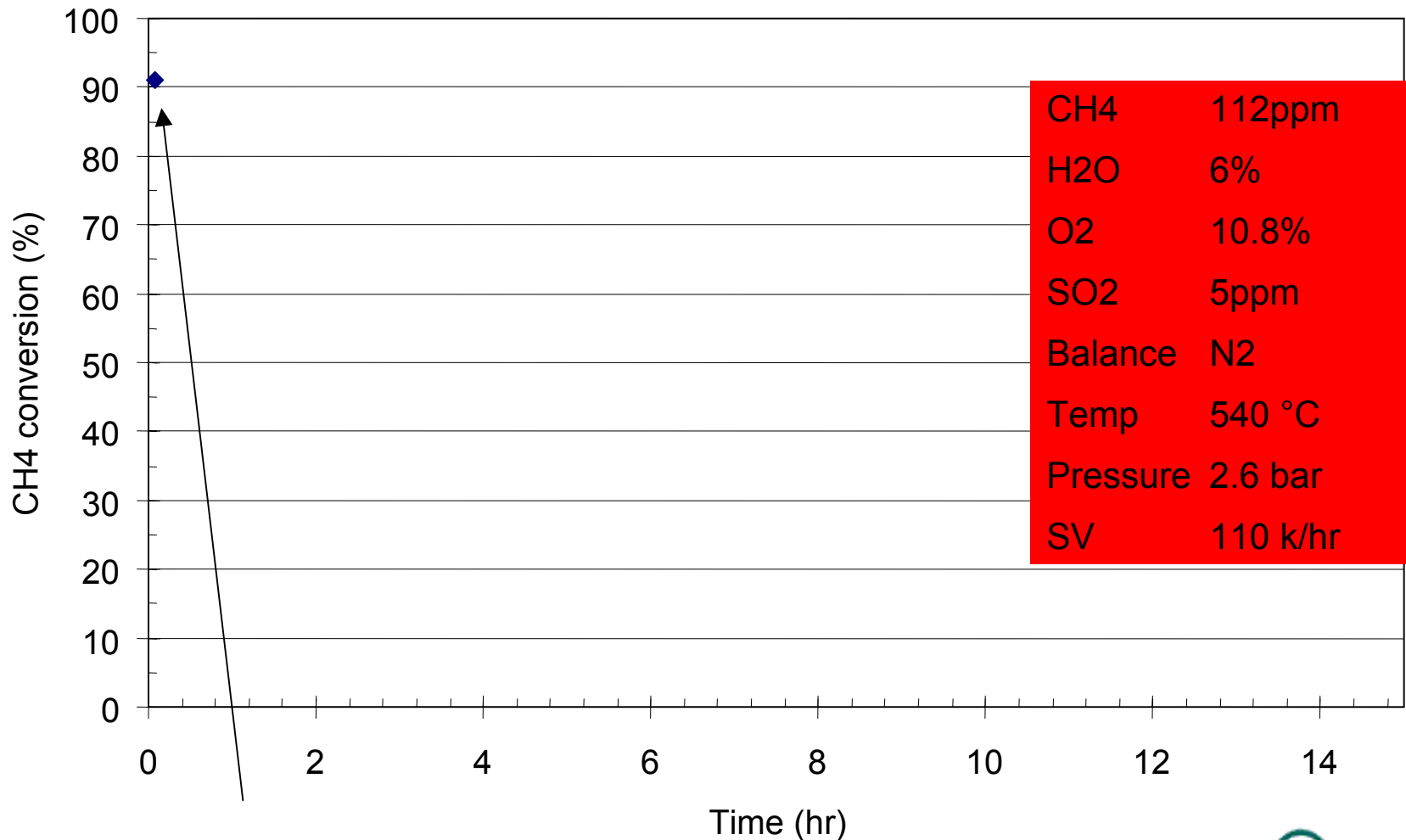
Need to use another type of catalyst

Pre-turbo catalyst



Higher conversions will require a different catalyst

CH₄ conversion and Pd catalyst

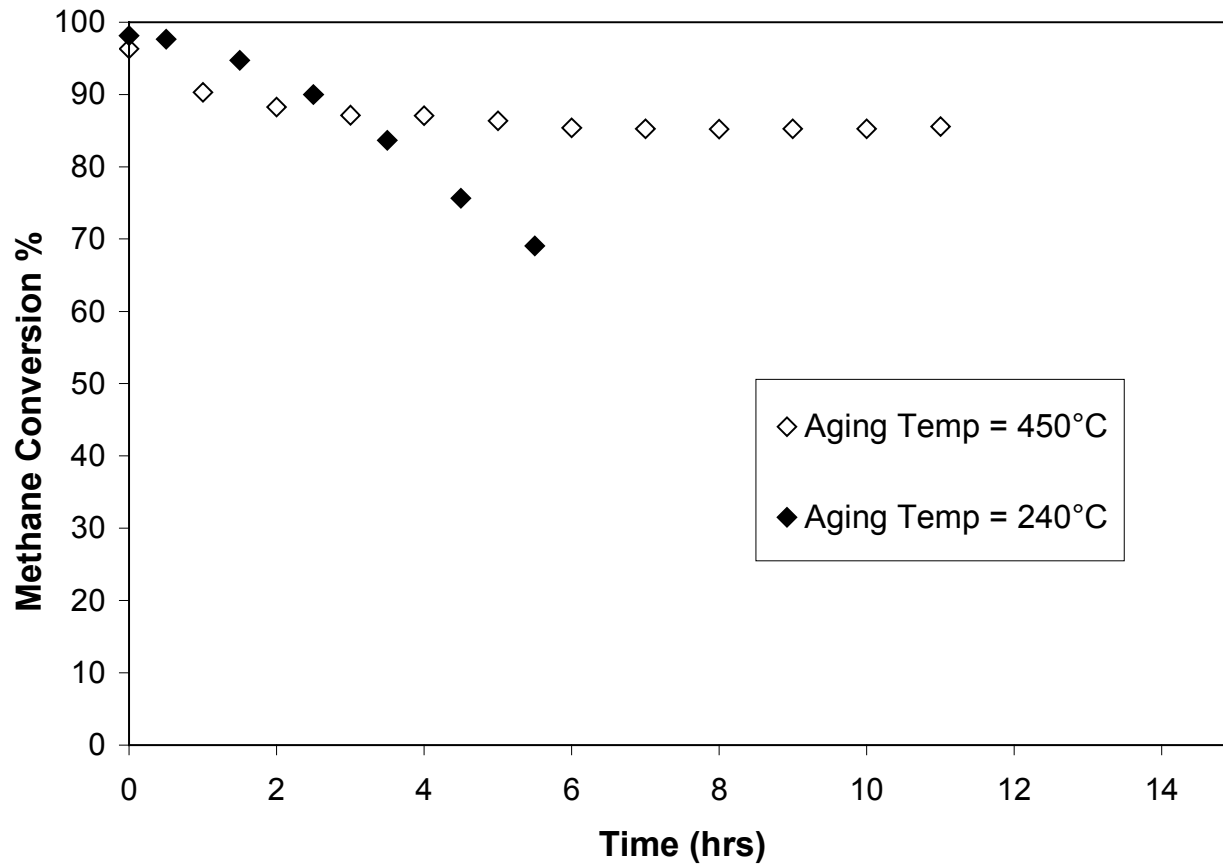


Pd catalyst can provide fairly high conversions of CH₄

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Deactivation with time



Aging with 5 ppm SO₂

Role of sulfur in catalyst deactivation

- SO_2 adsorbs strongly on Pd
- The resulting PdO- SO_3 sites possess low activity for HC oxidation



- Methane is the most sensitive to SO_2 poisoning

What do we do next?

- Pd based catalyst is an interesting alternative but has serious durability issues
- Need to frequently replace catalyst
- Need to regenerate catalyst on a regular basis
 - Similar strategies have been developed for NO_x storage catalysts in GDI engines
 - Use of Diesel NO_x storage catalysts also require periodic catalyst regeneration
 - Will need system approach between engine OEM and catalyst supplier
- Can we actually regenerate methane catalyst?

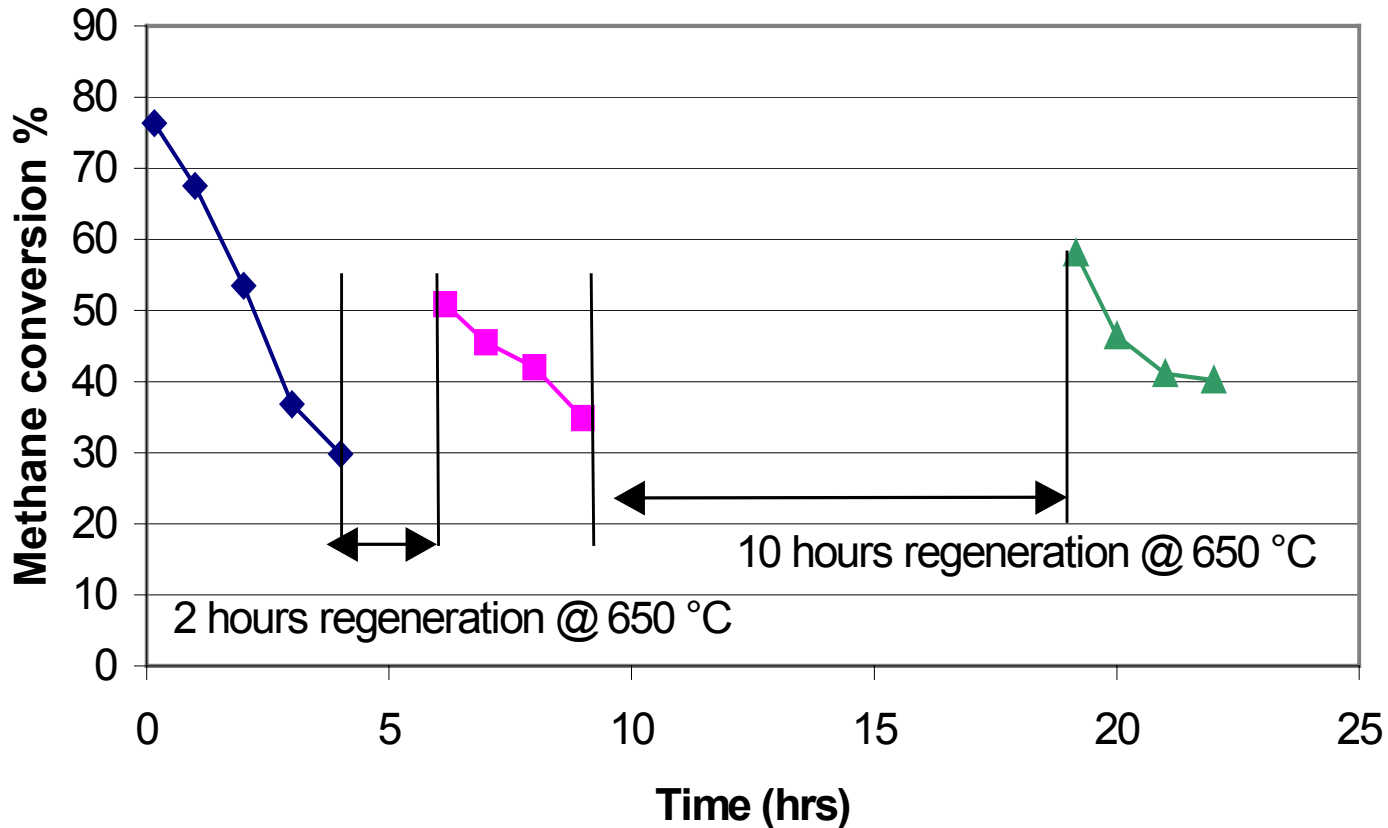
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Methane catalyst regeneration

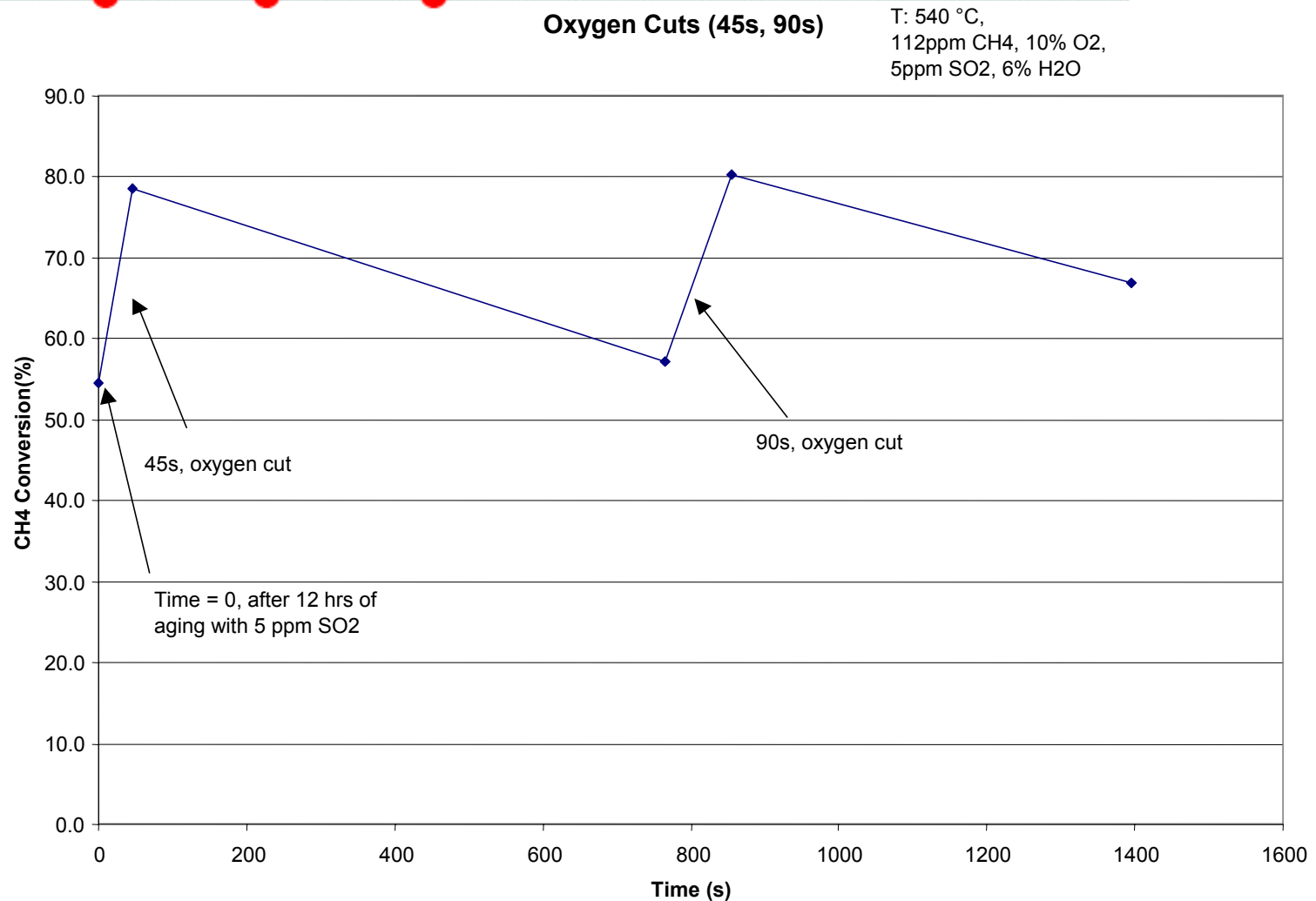
- Thermal regenerations
- Rich regeneration strategies
 - With oxygen cuts
 - With H₂
 - With H₂ & CO
 - With gas mixtures

Thermal regeneration



Thermal regeneration is not an option

Rich regeneration (oxygen cuts)

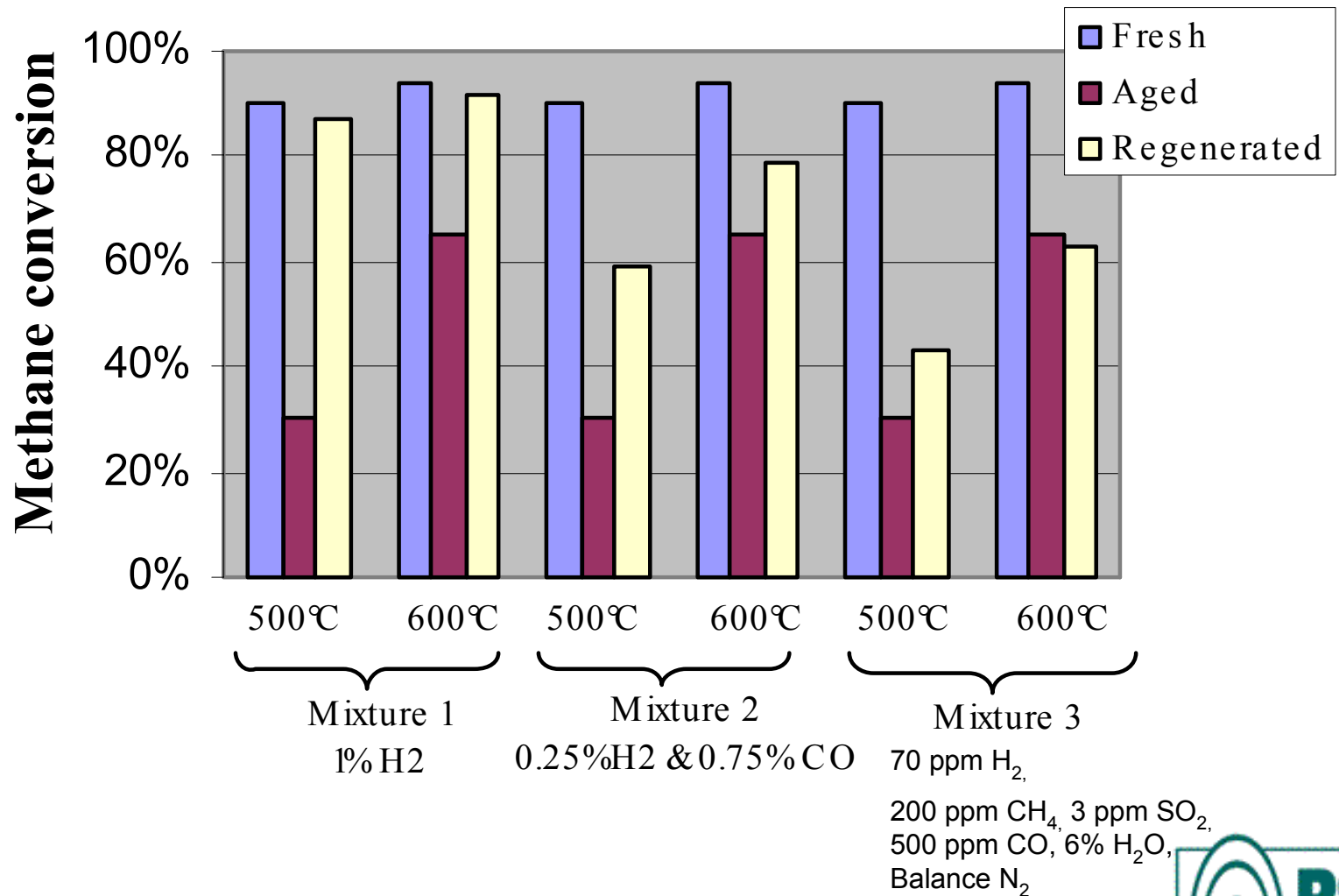


Oxygen cut is an option but is not practical

Regeneration considerations

- From literature, H₂ is a good chemical for regenerating Pd catalysts
- H₂ could be produced by the engine when $\lambda < 1$
- CO can also be used as a reducing agent but is less efficient than H₂

Regeneration results



Results

- Mixture 1: complete regeneration
- Mixture 2: partial regeneration
- Mixture 3: partial/lower regeneration than mixture 2

- In actual engine conditions (mixture 3), catalyst will have to be exposed longer to regeneration conditions



Questions?