

Thermodynamic Analysis of Methanol Steam Reforming Conditions for HT-PEMFC Feeding: An Aspen Plus® Study

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Overview

Methanol is a promising hydrogen carrier for HT-PEMFC systems. However, reformer operating conditions affect both reformat quality and thermal integration. This work uses Aspen Plus to identify operating conditions that balance CO formation and thermal self-sustainability.

Methanol can be produced from renewable H₂ and captured CO₂, and is easier to store and transport than hydrogen. In MeOH/HT-PEMFC systems, the steam reformer determines both:

- reformat composition;
- heat demand of the system.

Objective: identify reformer conditions that provide acceptable CO content and sufficient heat recovery.

Aim of the study

To identify reformer operating conditions able to balance:

- high H₂ content;
- acceptable CO concentration;
- sufficient heat recovery from the catalytic burner;
- thermal self-sustainability of the reforming section.

Aspen Plus® Model

Fixed Parameters	Value
Nominal Power	5 kW
Stack Temperature	160°C
Number of Cells	120
H ₂ utilization	0.74
Reformer model	RGibbs
Burner Exhaust temperature	270°C
Thermodynamic method	Peng Robinson
Fixed Parameters	Value
Reformer Temperature	240 – 300°C
MeOH content in Feed	50 – 70 vol%

Introduction

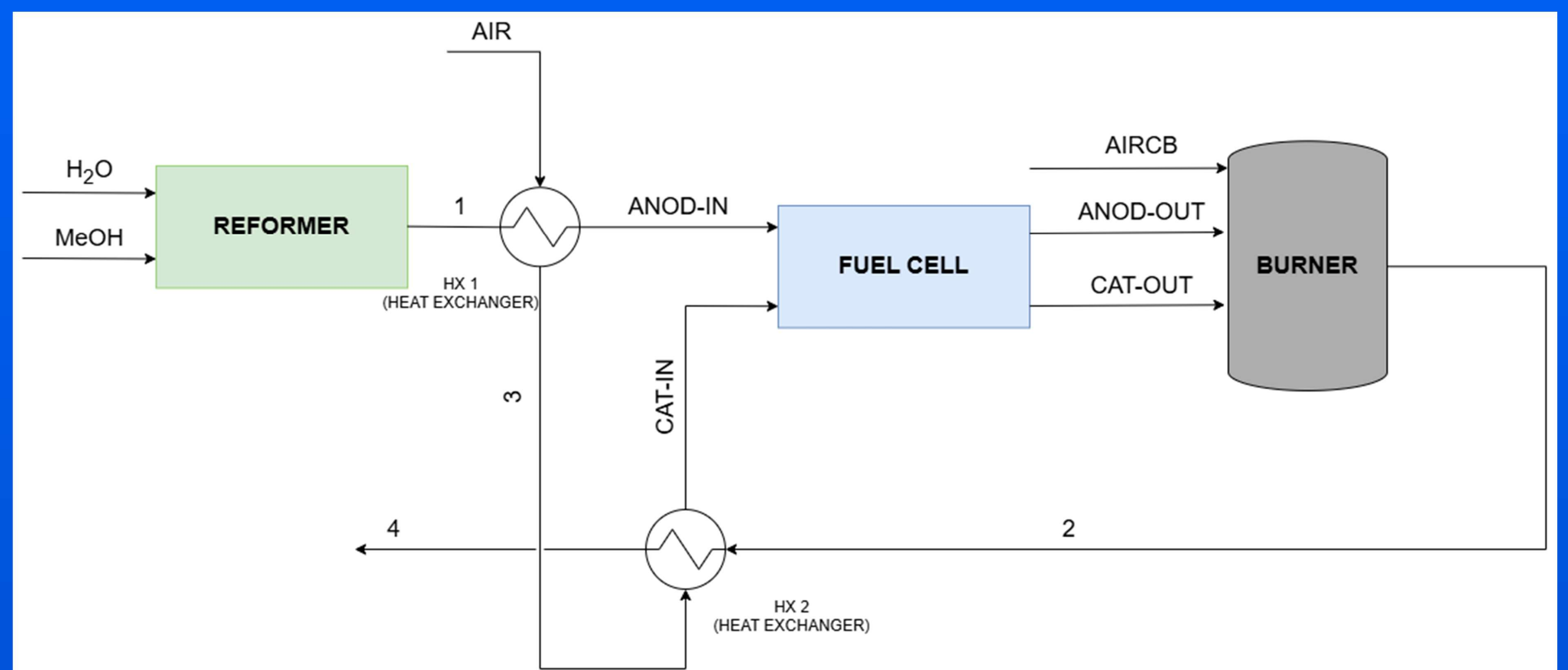


Figure 1: Simplified process flow diagram of the integrated MeOH reformer / HT-PEMFC system.

Performance Indicators

Reformat quality

- Dry H₂ content
- Dry CO content

Thermal self-sustainability

$$TSI = \frac{Q_{burner} \cdot \eta_{HR}}{Q_{reformer}}$$

$$TSI \geq 1$$

means that recoverable burner heat can cover reformer heat demand.

Results

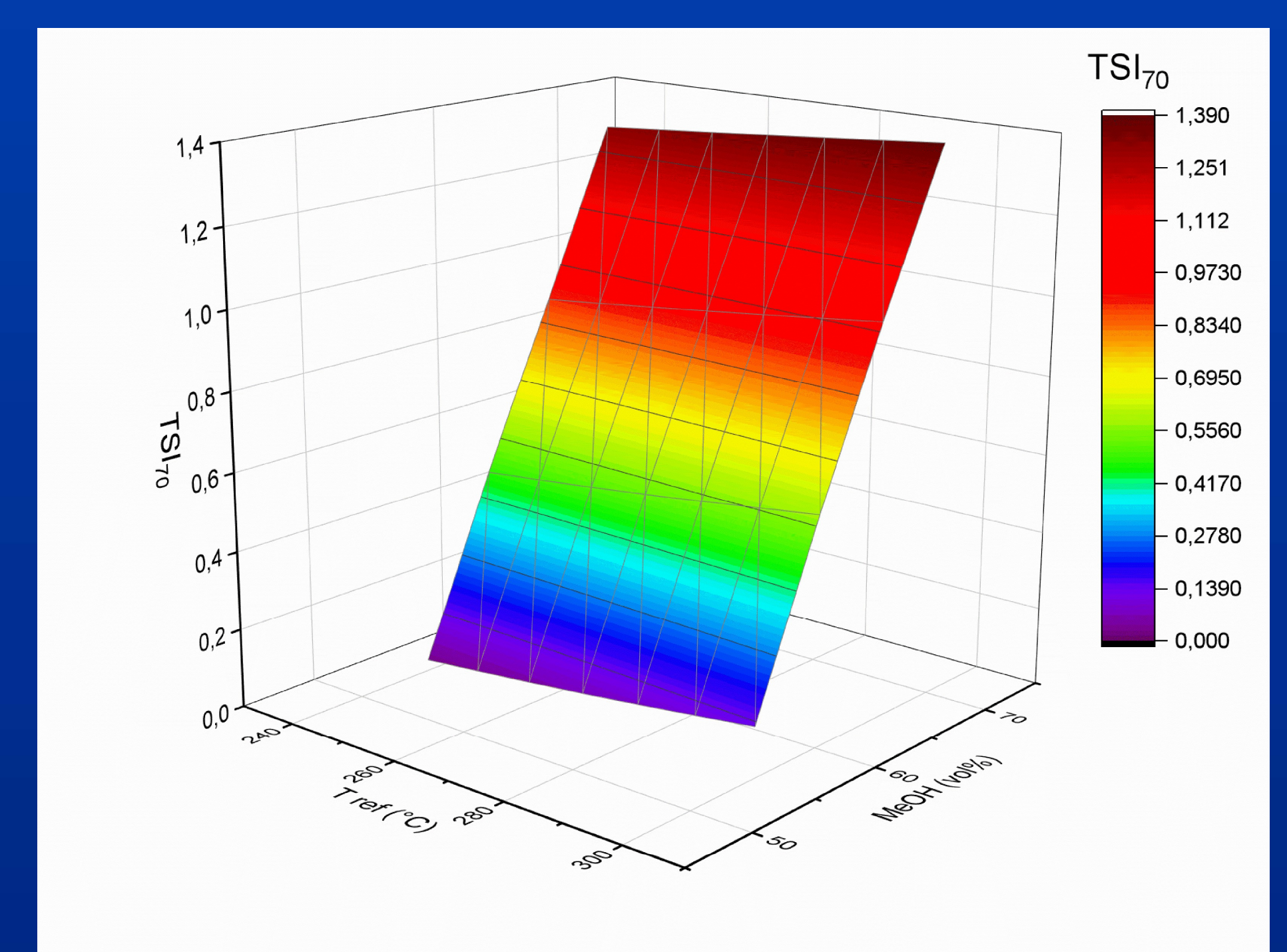
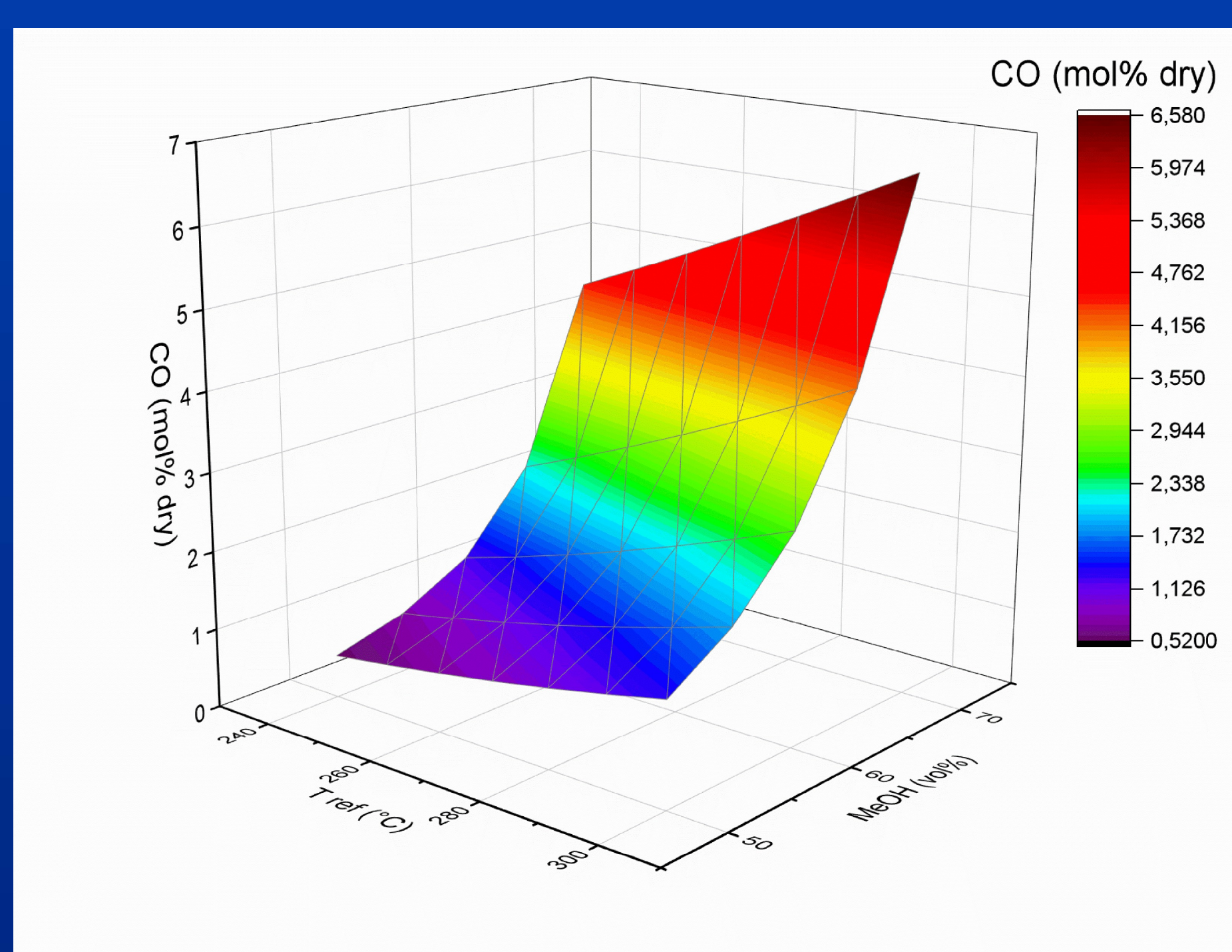
Trade-off

The favorable operating window was:

$$CO_{dry} \leq 3 \text{ mol\%}$$

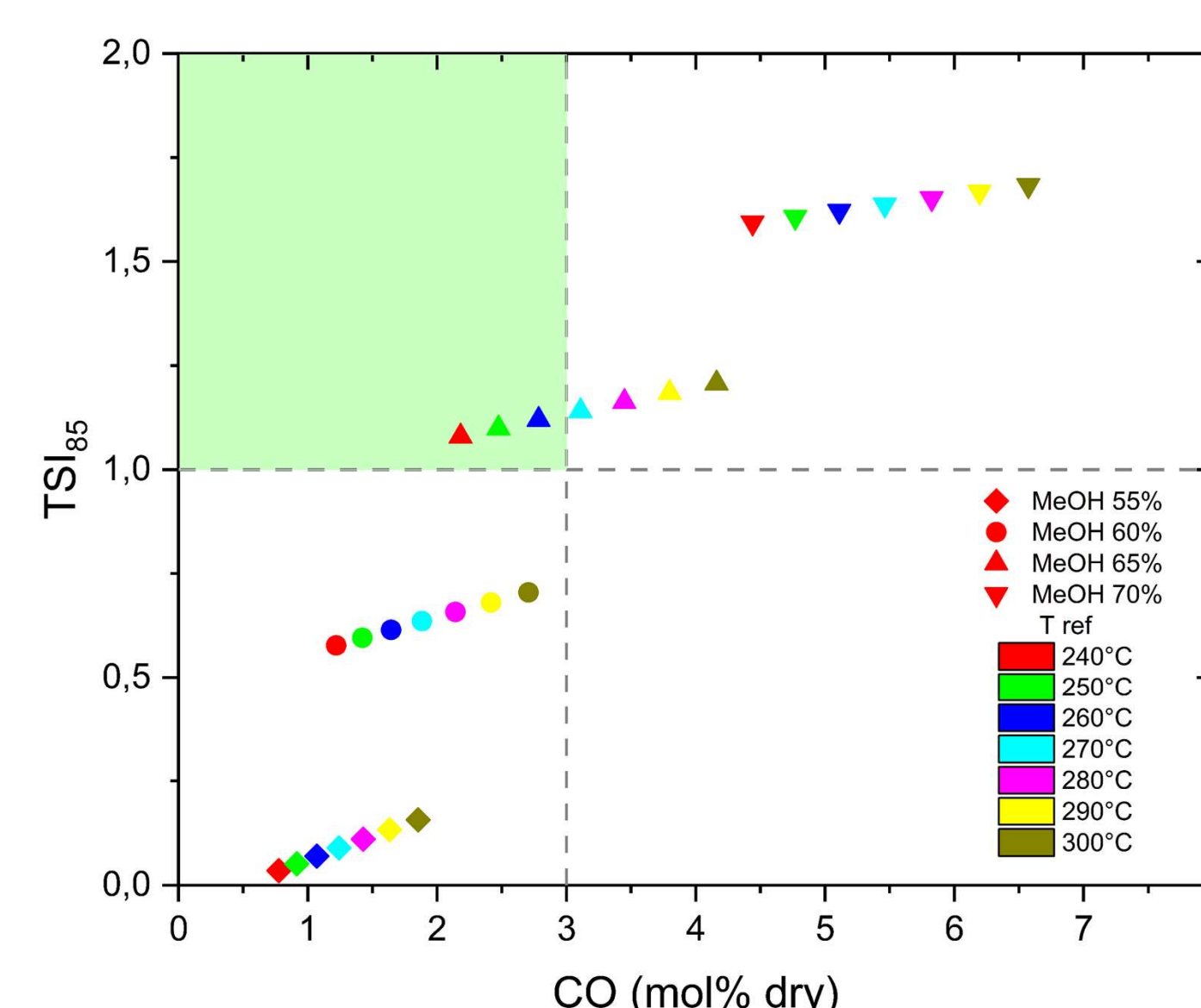
$$TSI \geq 1$$

- Low MeOH → lower CO, but insufficient TSI.
- High MeOH → higher TSI, but excessive CO.
- 65 vol% MeOH gives the best compromise.



Reformat quality

- H₂ content remains high and stable: 73–75 mol% dry.
- CO increases with:
 - reformer temperature;
 - MeOH content.



Thermal balance

- Higher MeOH content increases burner heat release.
- TSI increases mainly with MeOH content.
- Better thermal self-sustainability leads to higher CO formation.

Conclusions

Overall, this study highlights that the design of methanol reformer/HT-PEMFC systems should not focus only on hydrogen production, but also on CO formation, burner heat recovery, and system-level thermal integration. The key challenge is to identify operating conditions that balance reformat quality and thermal self-sustainability.

Acknowledgements

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