Estimation of Fuel Saving for Combined Heat and Power System by Chemical Recuperation

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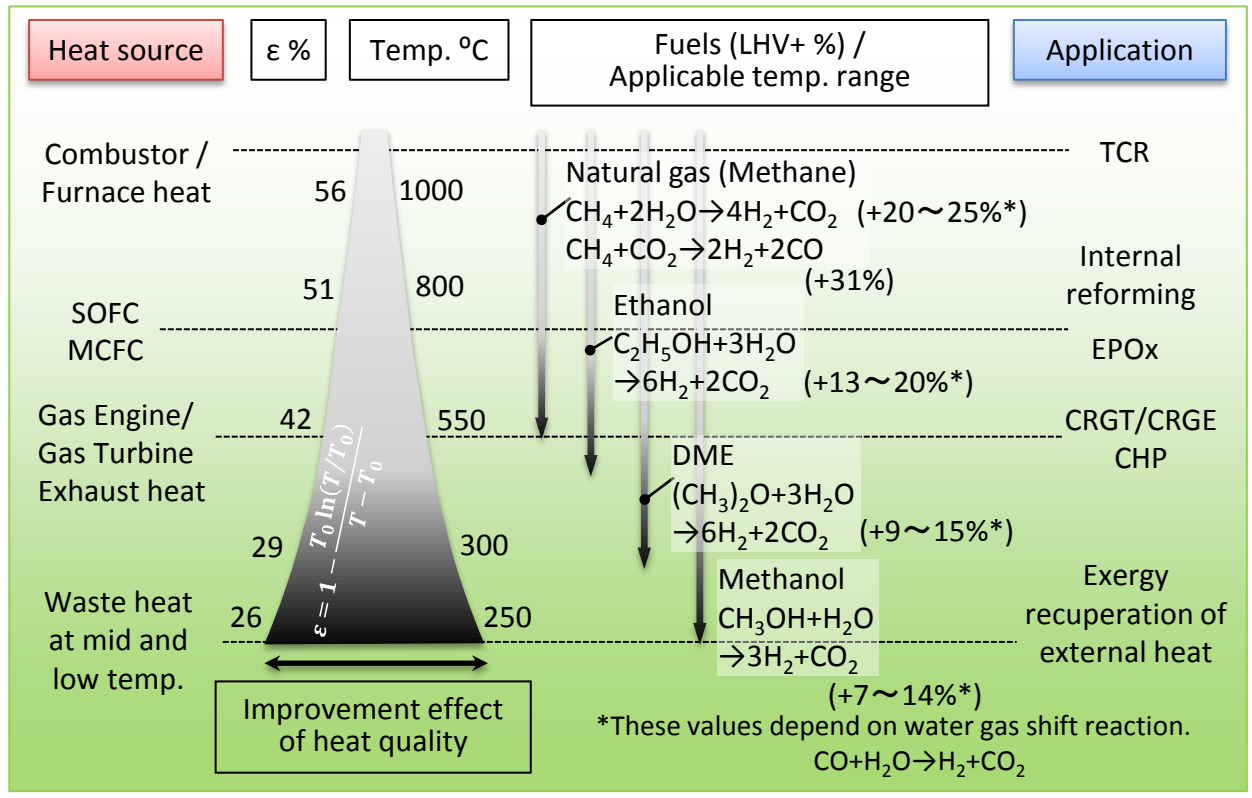
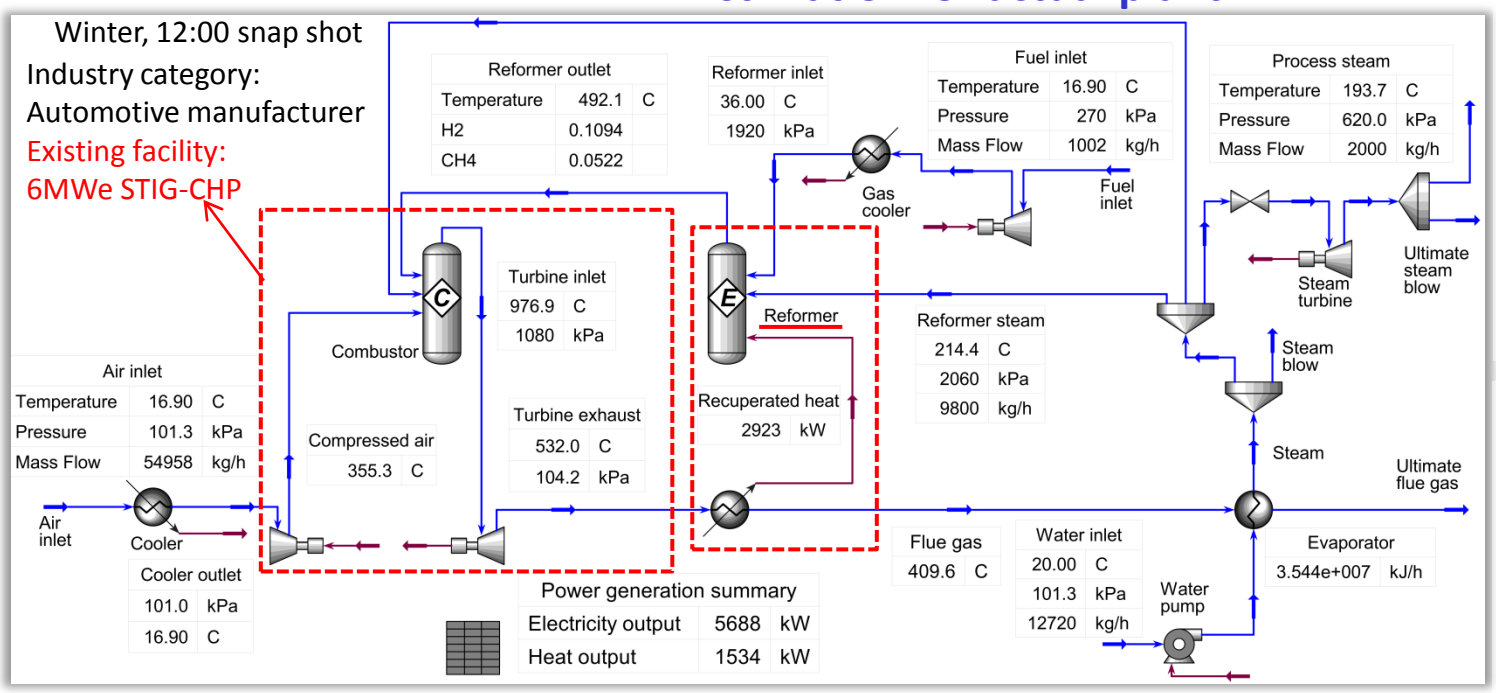
Conclusions/Summary

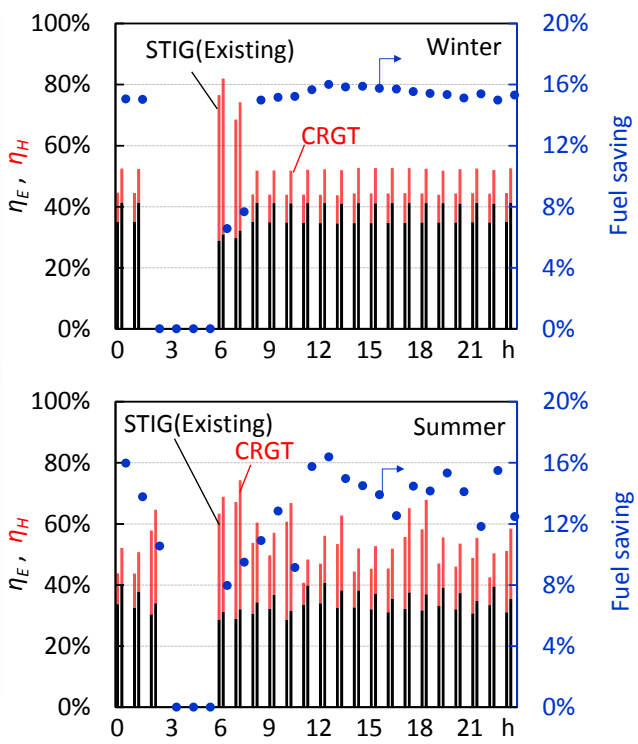
This poster explains basic concept and industrially-feasible applications of the unconventional and non-cascadic use of heat. Nowadays, electrified life style pushes up demand of power rather than heat, so power generation efficiency become more important. Hydrogen is a unique fuel in terms of "exergy recuperation" in which degrading fossil fuel into hydrogen can take low quality heat up to availability of 83% as a kind of chemical heat pump. CRGT (Chemically Recuperated Gas Turbine) is a specific example that can increase power generation efficiency and expand the range of ratio between heat and power by recovering the exhaust heat with endothermic reaction of steam reforming. This study quantified the effect of modifying existing STIG (Steam Injected Gas turbine) CHP system in an actual plant into CRGT. The results indicate that the CRGT can reduce the fuel consumption by 15% in winter season in comparison with the existing system. Steam reforming of dimethyl ether (DME) occurs below 300 degree-C in equilibrium, but lowering reaction temperature is a challenge. We are now testing many catalysts and a couple of Nickel based catalysts supported on SiO_2 can produce only hydrogen and carbon mono oxide without methanation.

Unused heat temperature / Applications of chemical recuperation



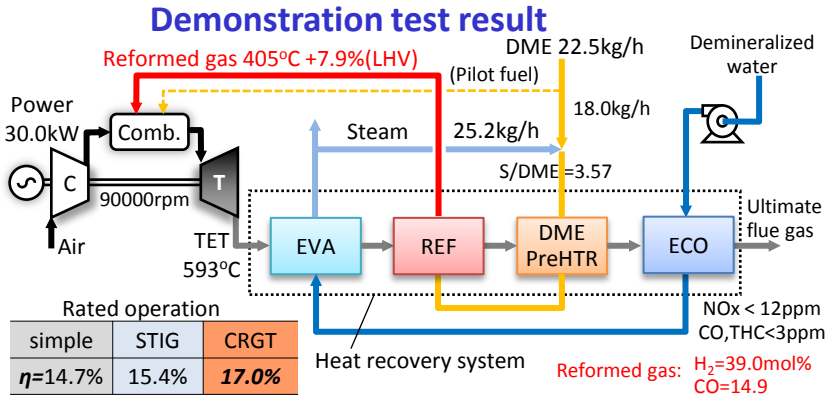
Estimation for actual plant





Process Flow Diagram: ASPEN HYSYS®

Demonstration test result



Rated operation

simple	STIG	CRGT
η=14.7%	15.4%	***17.0%***

Challenge: Low temperature reforming catalyst

DME→MeOH hydrolysis $(CH_3)_2O + H_2O \rightarrow 2\mathbf{CH_3OH}$ ΔH=23.6kJ Solid acid: Zeolite

Conventional catalysts

$\mathbf{CH_3OH} \rightarrow HCHO + H_2$

H_2O $HCOOH + H_2$

Dehydrogenation

$CO_2 + 3H_2$

$CH_3OH + H_2O \rightarrow CO_2 + 3H_2$

ΔH=48.3kJ

*By-product: Methanation

$CO + 3H_2$

$\mathbf{CH_4} + H_2O$

ΔH=−206kJ (Exothermic)

Precious metal catalysts

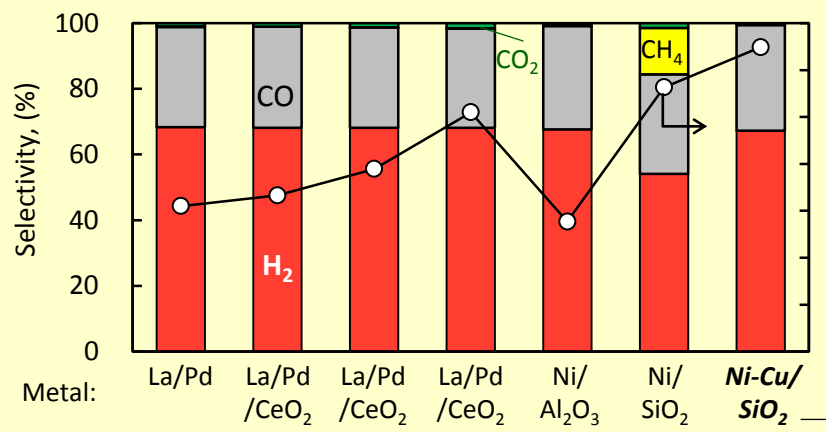
$2\mathbf{CH_3OH} \rightarrow 2CH_3O(a)+2H(a)$

$HCOOCH_3(a) + H_2$ H_2

$2CO + 2H_2$

$CH_3OH \rightarrow CO + 2H_2$

ΔH=90.7kJ



Steam/DME	3.5
GHSV h^{-1}	4050
Temp. °C	300
Pressure atm	1

Result of steam reforming test