INVESTIGATION AND RECOVERY OF FLARE GAS USING A MEMBRANE SEPARATION UNIT TO ENHANCE METHANOL SYNTHESIS PRODUCTION IN THE PRESENCE OF CATALYST DEACTIVATION

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INTRODUCTION

This research focuses on the recovery of flare gas of the world's largest methanol complex, located in Pars Special Economic Energy Zone of Iran. The work aiming at an increase of methanol production and process efficiency by utilizing flare gas components in an environmentally friendly way. Methanol is produced by the catalytic conversion of the synthesis gas over a commercial catalyst (Figure 1). Important Reactions are shown in Eq. 1-3.

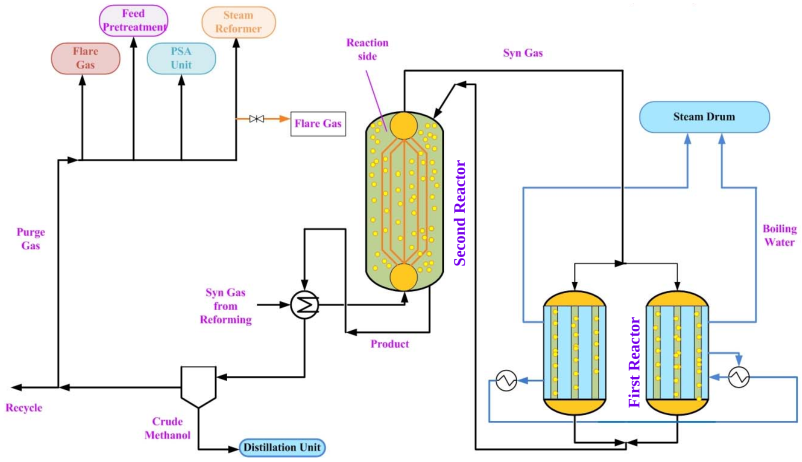

Figure 1: Schematic diagram of the methanol production unit

$$CO + 2H_2 \leftrightarrow CH_3OH \qquad \Delta H_{298} = -90.00\ kJ/mol \qquad \text{Eq. 1}$$
$$CO_2 + 3H_2 \leftrightarrow CH_3OH + H_2O \qquad \Delta H_{298} = -49.43\ kJ/mol \qquad \text{Eq. 2}$$
$$CO_2 + H_2 \leftrightarrow CO + H_2O \qquad \Delta H_{298} = +41.12\ kJ/mol \qquad \text{Eq. 3}$$

MATHEMATICAL MODEL

A one-dimensional steady state model has been used for this fixed-bed reactor to determine the concentration and temperature distributions inside the reactor. To obtain the mole and the energy balance equations, a differential element along the axial direction inside the reactor was considered [1-3]. The simulation of the novel process chain is shown schematically in Figure 2.

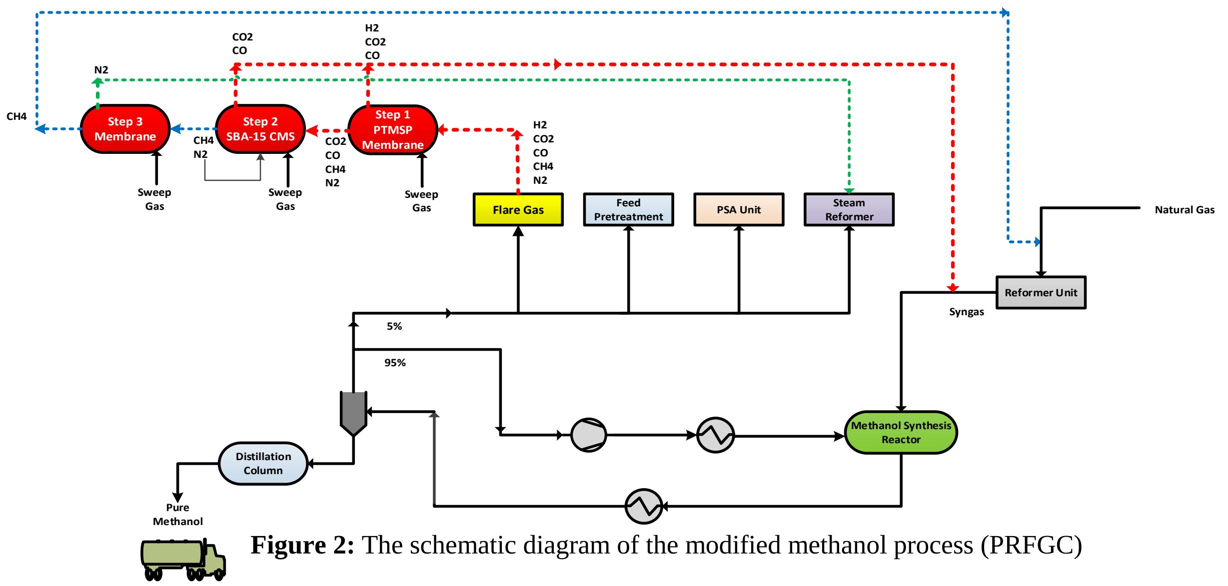

Figure 2: The schematic diagram of the modified methanol process (PRFGC)

RESULTS

The developed steady-state model was validated under industrial conditions and the results of simulation with daily-real plant data were in very good agreement. The achieved simulation results from comparison of Industrial Configuration (IC), Recycle Flare Gas Configuration (RFGC) and purposed strategy, named as Purified Recycle Flare Gas Configuration (PRFGC), are illustrated in Figure 3 & 4.

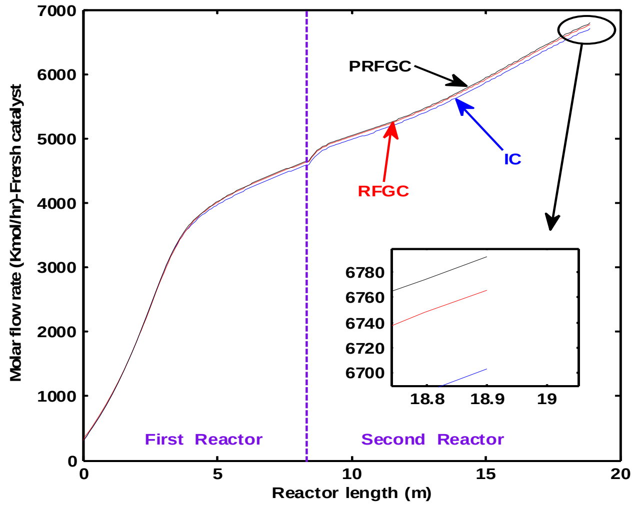

Figure 3: Methanol production along the reactor length

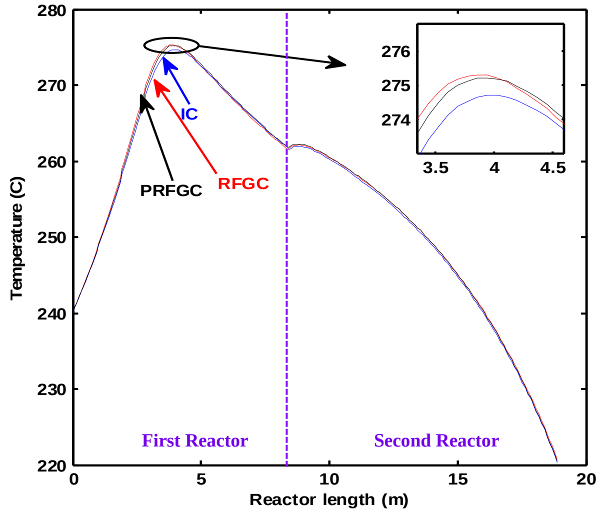

Figure 4: Temperature along the reactor length

Consequently, the methanol production rate obtained from the modified process PRFGC is significantly more than with IC. The reason of lower methanol production in RFGC in comparison with PRFGC is the inert gas increase in the reaction medium. The loss of catalyst activity, which corresponds to the loss of active surface area, is due to thermal sintering in commercial low-pressure $CuO/ZnO/AL_2O_3$ catalysts (Figure 5). The effect of specific catalyst deactivation is considered in the model.

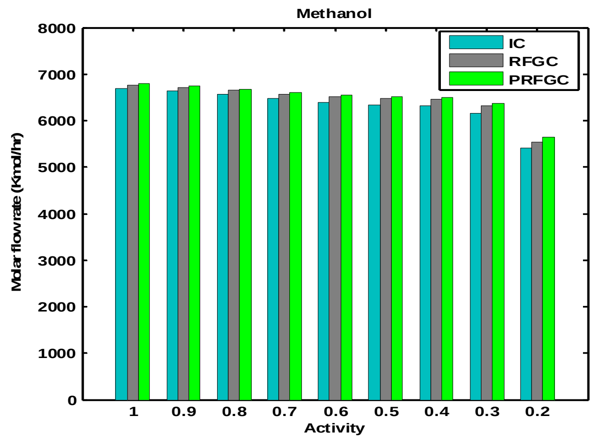

Figure 5: Influence of catalyst activity on the performance of methanol production

CONCLUSION

- A novel recovery-process is presented: PTMSP and SBA-15/CMS membranes are used to separate H_2, CO and CO_2 from the flare gas. An additional membrane separates CH_4 from N_2.
- Up to 17.3 ton/h of flare gas (60% H_2, 20% CO & CO_2, 20% N_2 & CH_4) can be reused.
- 12-14 million US-$ annual profit increase due to the increased methanol production is possible.
- With the modified process chain emission of more than 30300 ton/year of CO_2 to the atmosphere can be prevented by recovering flare gas to the methanol production process.

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