Study on the wall heat transfer of condensation in the presence of NC gases

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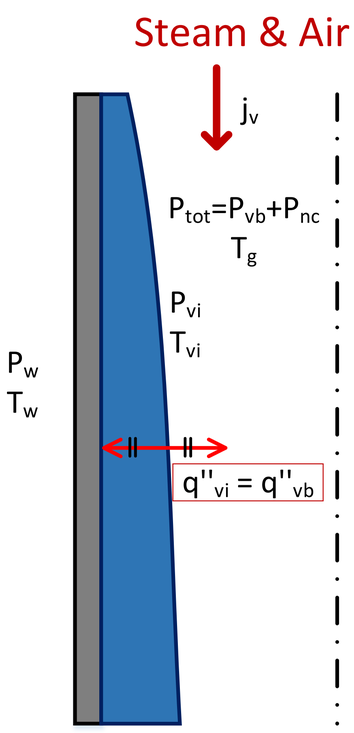
Background and Objective

- **Wall film condensation phenomena is occurred near a cold wall when hot steam flows into internal or external flow channel along the wall.**
- **The Colburn-Hougen model(1934) has been widely used in T-H system code like as MARS, TRACE, RELAP and SPACE to predict the influence of NC gases on condensation.**
- **Objectives of this paper**

This study aims to clarify the effect of NC gases on wall heat transfer with the present model for wall condensation with different amount of NC gases.

Colburn-Hougen model

- **Basic concept**



Heat flux from the liquid film to the wall $q''_{vi} = h_{cond}\left(T_{vi} - T_w\right)$

Heat flux due to condensation of vapor mass (j_v) flowing toward the liquid-vapor interface

$$q''_{vb} = j_v \cdot i_{fg,b}$$

$$= h_m \frac{\rho_{vb}}{x_{vb}} \ln\left(\frac{1 - P_{vi}/P}{1 - P_{vb}/P}\right) \cdot i_{fg,b}$$

Why???

In a rare steam condition,

- ✓ $T_{vi} \sim T_{sat}\ (P_{steam})$
- ✓ T_w ~ very low temp.
- ✓ $q_{vi} = q_{vb} \sim 0$ & htc << small

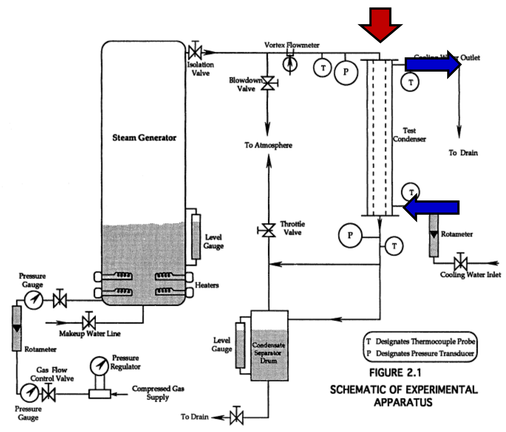
T_{liq} ???

- ➔ $T_{liq\_cal} >> T_{liq\_real}$ && $T_{gas\_cal} >> T_{gas\_real}$
- ➔ **Need to be Added H_{conv} between wall and liquid film**

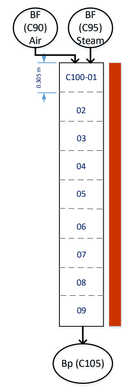
Assessment

- **MIT experiments(Siddique, 1992) were conducted under forced convection conditions with different NC gases**

Run no.	Inlet Air mass fraction	Inlet Temp.	Inlet Press	Steam inlet flow rate	Air inlet flow rate
	(-)	(℃)	(Mpa)	(kg/s)	(kg/s)
7	0.08	119.9	0.209	2.609E-03	2.277E-04
18	0.12	100.0	0.110	5.562E-03	7.386E-04

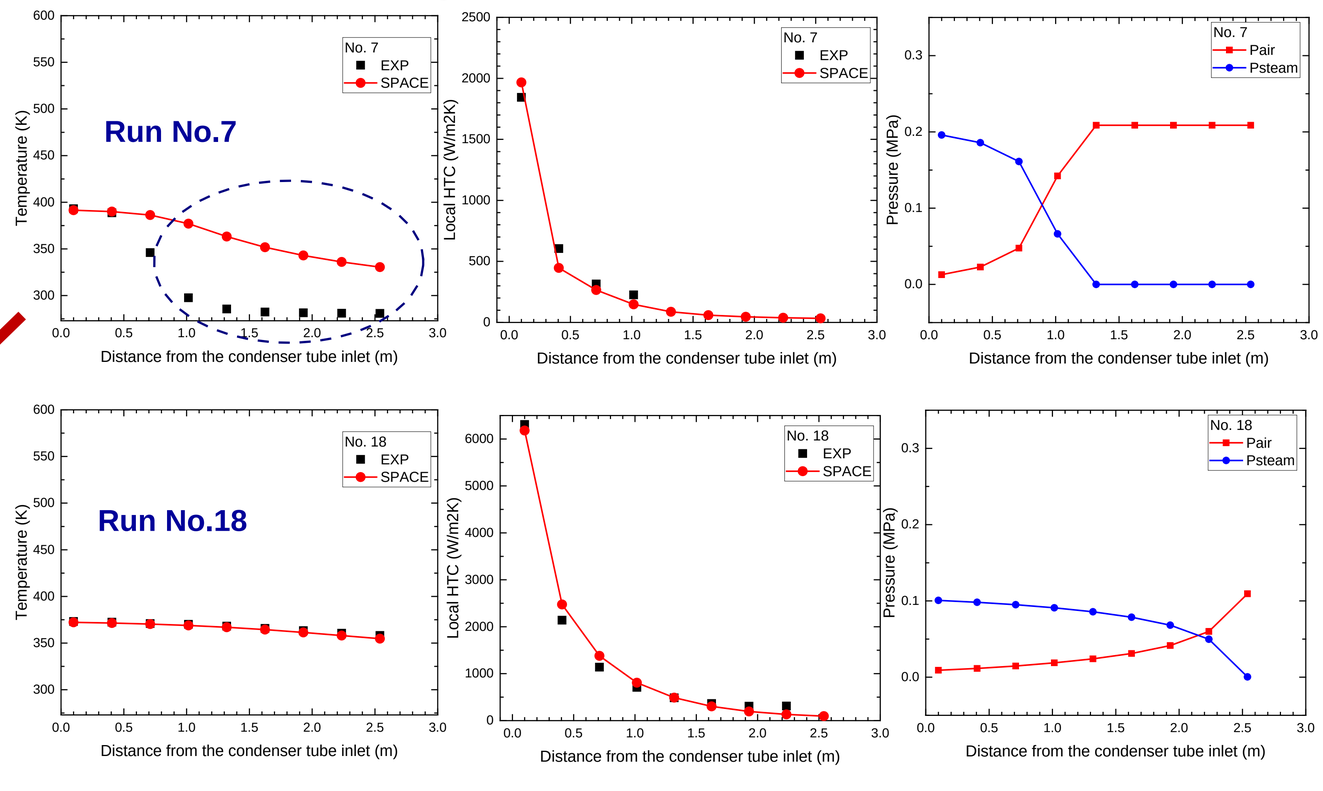


< MIT test loop >

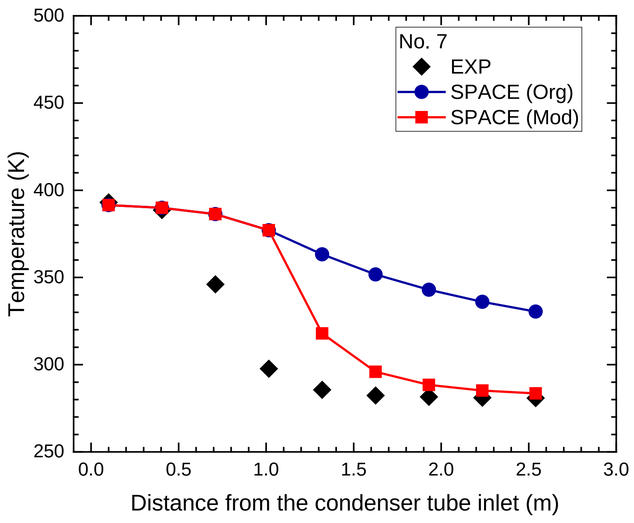


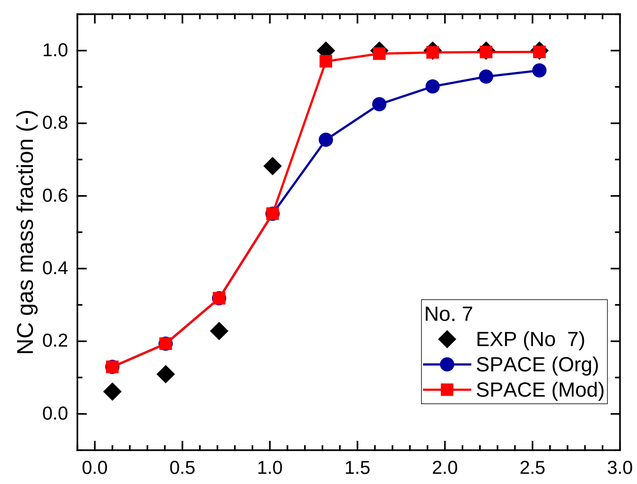
< SPACE modeling >

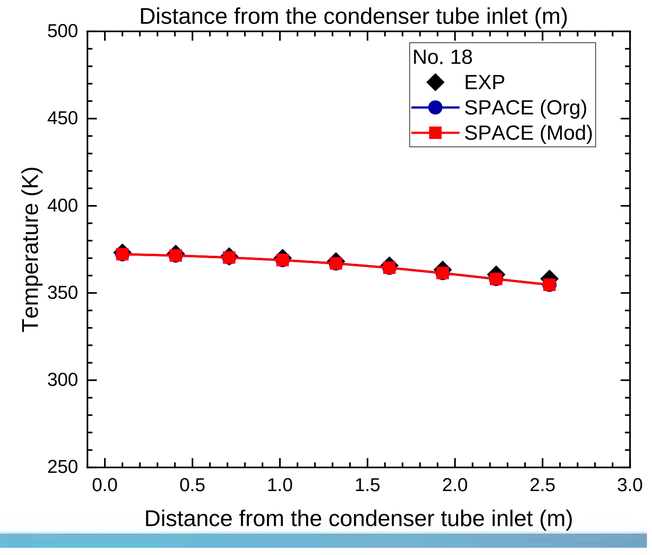
- **Preliminary calculation**



Gas mixture temperature at the centerline of pipe | **Local HTC (from wall to gas mixture)** | **Partial press along the pipe (EXP)**







Conclusions

- **Wall film condensation in the presence of NC gases has used the Colburn-Hougen model as a default model in the SPACE code.**
- **As NC gas mole fraction is higher, the discrepancy of gas mixture temperature in the liquid film-wise condensation condition between EXP. and the SPACE results was occurred**
- **By considering wall heat transfer to liquid phase in a rare steam condition, the SPACE can predict well with EXP. data.**