Development of a integration program for the dynamic analysis of a VHTR-SI process(I)

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1. Introduction

The sulfur-iodine(SI) cycle and the Westinghouse hybrid sulfur cycle coupled to a very high temperature gas-cooled reactor(VHTR) are well known as a feasible technology to produce hydrogen.[1]

The concentration of the sulfuric acid solution and its decomposition are essential parts in both cycles.

In this study, we established a tentative process diagram based on the He-thermal pathway for an integration of a dynamic code for the VHRT-SI process. Also, we developed a dynamic program for the main equipment in that process.

2. Methods and Results

The target equipment for a dynamic analysis are a sulfuric acid distillation column, sulfuric evaporator and sulfur trioxide decomposer. The simulation code of each equipment was programmed based on a mathematical modeling for a dynamic calculation behavior.

Fig.1 shows the initial window including a diagram of the SI-process based on the He-thermal pathway. In figure 1, the He-stream is the gray line and the process gas line is the green line. Finally our conclusion on the He-thermal pathway will be established by discussing it with nuclear reactor system experts and an intermedium heat exchange loop expert in the future.

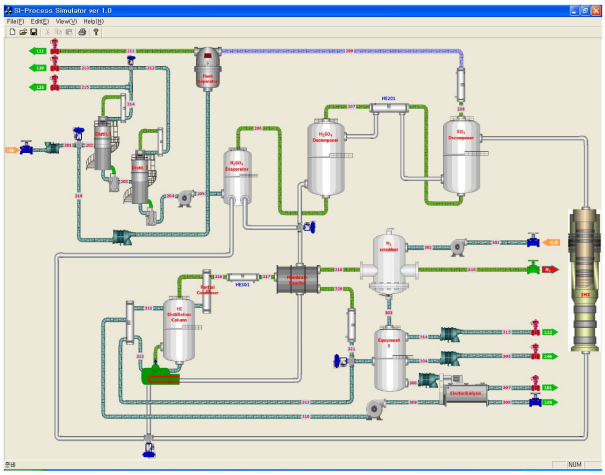

Fig. 1. Initial window including a diagram of the SI-process based on the He-thermal pathway.

a. Sulfuric acid distillation

Figure 2 shows the modeling and signal flow for a distillation column.[2] In the figure 2, the model of a distillation column is consisting of feed line, reboiler and n-th stage of plate.

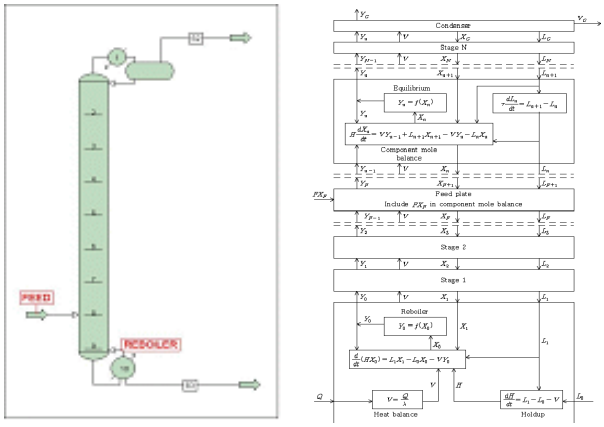

Fig. 2. Modeling and signal flow for a distillation column.

Figure 3 shows a typical calculation result including the sulfuric acid distillation column system. In figure 3, the simulation results can be represented in table or figure forms. Fig. 4 shows a typical calculation result including the sulfuric acid distillation column system.

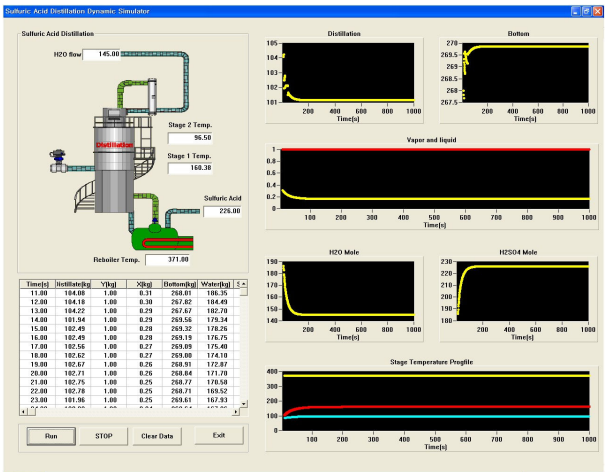

Fig. 3. Simulation results for a sulfuric acid distillation.

b. Sulfuric acid evaporation

We chose the short vertical tube evaporator for a calculation of the dynamic behavior. The modeling and flow sheet for a sulfuric acid evaporator has been shown in Figure 4.

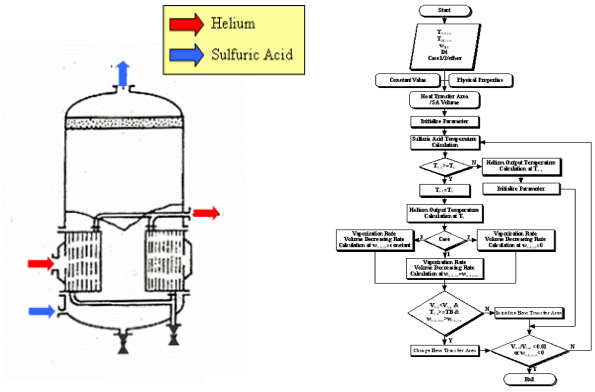

Fig. 4. Modeling and flow sheet for the dynamic simulation code of a sulfuric acid evaporator.

To simulate a sulfuric acid evaporator, we established an operation condition and an abnormal operation scenario. The context is the following;

1) Normal operation condition
   - 200 MWth production scale
   - Operation condition
     He flow rate : 10,250 mol/s
     Sulfuric acid(98%) flow rate : 533 mol/s
2) Abnormal operation scenario
   - Influence evaluation for variation of a sulfuric acid input amount
   - Influence evaluation for variation of the helium temperature

Figure 5 shows the simulation results under the condition of an abnormal operation.

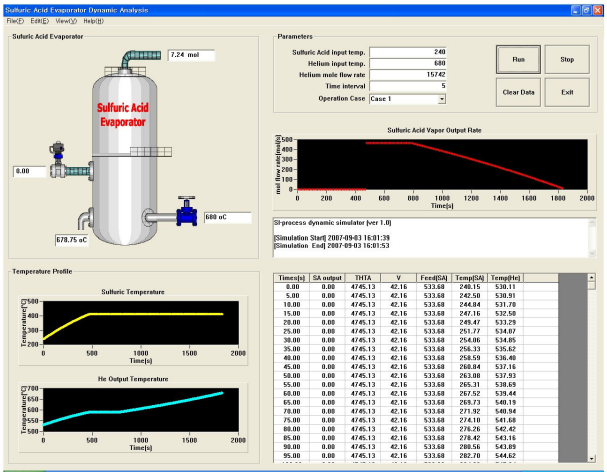

Fig. 5. Simulation results for a sulfuric acid evaporator.

c. Sulfuric trioxide decomposition

Figure 6 shows the typical simulation results for a sulfuric trioxide decomposer. The right graphs on the window are displaying the temperature profile and flow rate for the process gas and helium.

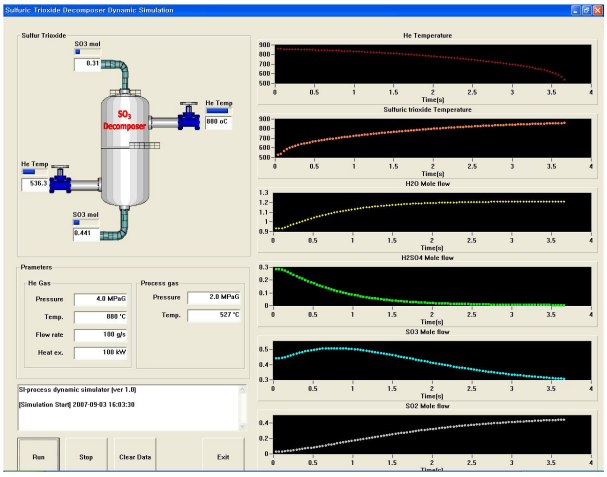

Fig. 6. Typical simulation results for a sulfuric trioxide decomposer.

3. Conclusion

The integration program for a dynamic simulation of the VHTR-SI process has been developed and its performance test has been successfully carried out.

Acknowledgments

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REFERENCES

[1]Brown LC, Besenbruch GE, Lentsch RD, Schultz KR, Funk JF, Pickard PS, Marshall AC, Showalter SK. High efficiency generation of hydrogen using nuclear power. 2003; GA-A24285.
[2]Heesung Shin, Dynamic analysis for a sulfuric acid distillation of the SI-process, KAERI, 2006.