Response to Reviewer 2 Comments

Comments and Suggestions for Authors

Manuscript ID: processes-1464182

Title: Research on high-pressure hydrogen pre-cooling based on CFD technology in fast filling process

Comments and Suggestions for Authors

The heat transfer and phase transformation of shell and tube heat exchangers are simulated at two-dimensional level. The influence of hydrogen inlet pressure, temperature and refrigerant flow rate on refrigerant phase transformation was studied, which has certain reference significance for hydrogen pre-cooling in hydrogenation stations. However, there are many things to be revised before publishing.

Author response:

Thank you very much for arduous work and valuable comments. We have studied the comments carefully and the following revision concerns have been well addressed accordingly. We appreciate your valuable and professional suggestions to improve the quality of our manuscript and the revised manuscript is highly expected to be suitable for publishing in processes.

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Point 1: FIG. 1 is too crude to describe the heat exchange mechanism.

Response 1: Thank you very much for your suggestions. The changes we made to Figure 1 are as follows. Figure 2 shows the temperature change of the hot and cold fluid during the heat exchange process[1,2]. t_1' and t_1'' represents the inlet and outlet temperature of the hot fluid, and t_2' and t_2'' represents the inlet and outlet temperature of the cold fluid.

Revise:

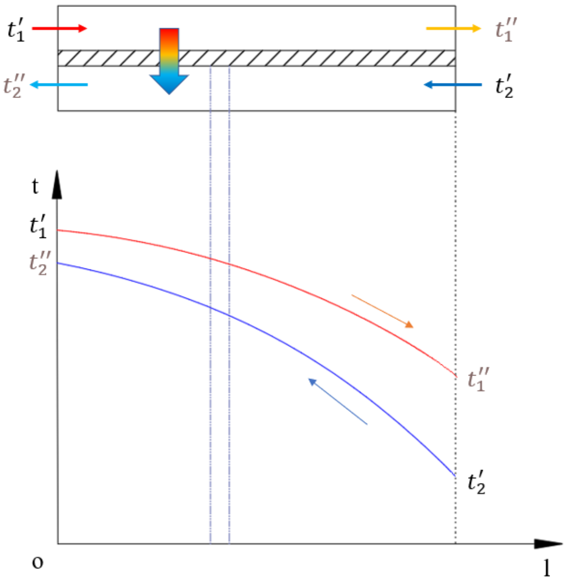

Figure 2. Heat transfer principle of shell and tube heat exchanger.

This revision is incorporated in the text on Line 122.

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Point 2: It is recommended to add the heat transfer flow chart of high temperature heat exchanger and low temperature heat exchanger, so that the text can be more intuitive to understand.

Response 2: Thank you for your valuable suggestion. We used a schematic diagram to show the flow of the high temperature cycle and the low temperature cycle[3-5].

Revise:

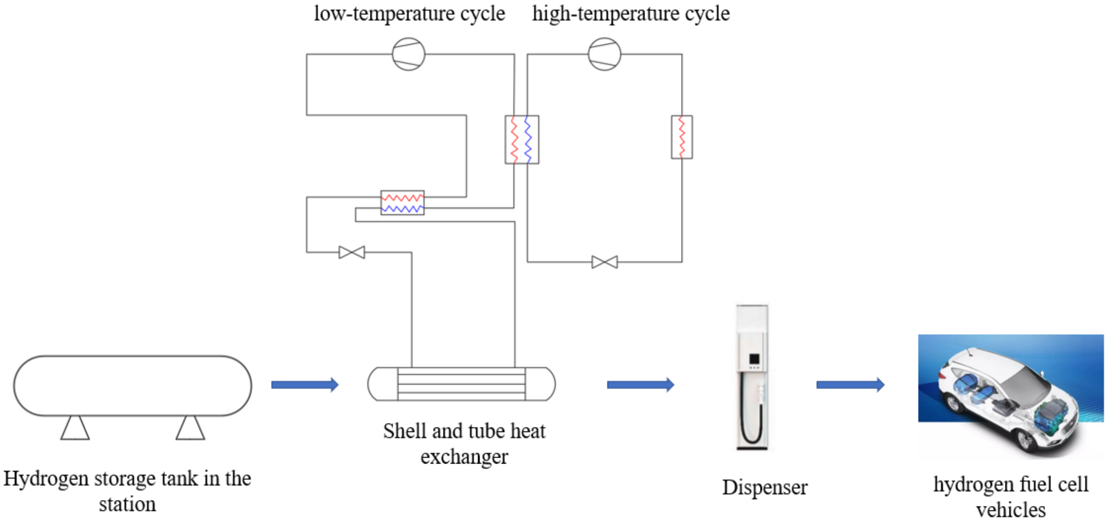

Figure 1. Schematic diagram of hydrogen pre-cooling system in hydrogen refueling station.

This revision is incorporated in the text on Line 111.

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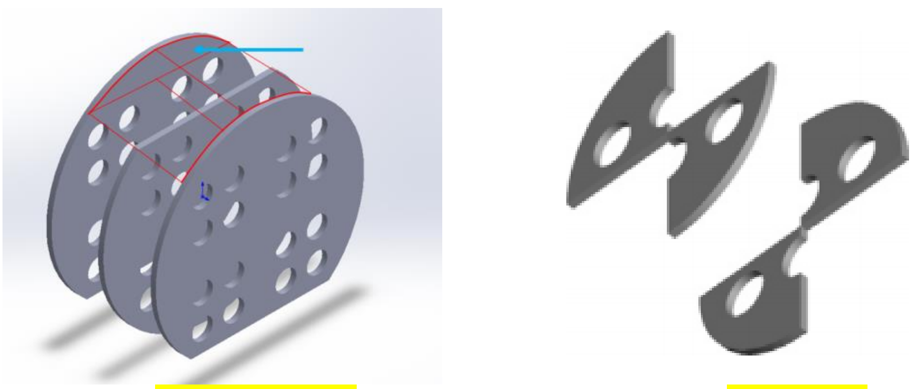
Point 3: FIG. 2 is suggested to be modified as the comparison of the "commonly used baffle" and the "flower baffle". Neither text nor pictures can tell the difference between the two baffles and why the "commonly used baffle" is not suitable.

Response 3: Thank you for your valuable suggestion. We use Figure 3 to illustrate the reason why the commonly used single bow baffle is inappropriate. The refrigerant R23 undergoes a phase change when heated, and the gas phase will gather in the area indicated by the arrow in the figure[6-10], which reduces the heat transfer performance of the heat exchanger.

Revise:

The commonly used single-curved baffle is shown in Figure 3 a). The refrigerant R23 undergoes a phase change when heated, and the gas phase will gather in the area indicated by the arrow in the figure, which reduces the heat transfer performance of the heat exchanger. This article uses the flower mentioned in [23-24] Type baffle to improve the heat exchange performance in the heat exchange process, as shown in Figure 3 b). The material of the heat exchange tube and the shell is 316L stainless steel. According to the actual working conditions in the heat exchange process, the average temperature difference method is used to design the heat exchanger. The geometric parameters are shown in Table 1. The three-dimensional model of the shell and tube heat exchanger is shown in Figure 4.



a) Single-curved baffle　　b) flower baffle

Figure 3. Single-curved baffle and flower baffle in shell and tube heat exchanger [23].

This revision is incorporated in the text on Line 130.

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Point 4: The structure parameters of heat exchanger in the table are too abstract. It is suggested to supplement the structure diagram of heat exchanger. Whether these data are parameters of the simplified model? they should be marked on the simplified model in FIG. 3 accordingly.

Response 4: Thank you for your valuable suggestion. The three-dimensional model of the shell and tube heat exchanger is shown in Figure 4. The modifications to Figure 3 are as follows

Revise:

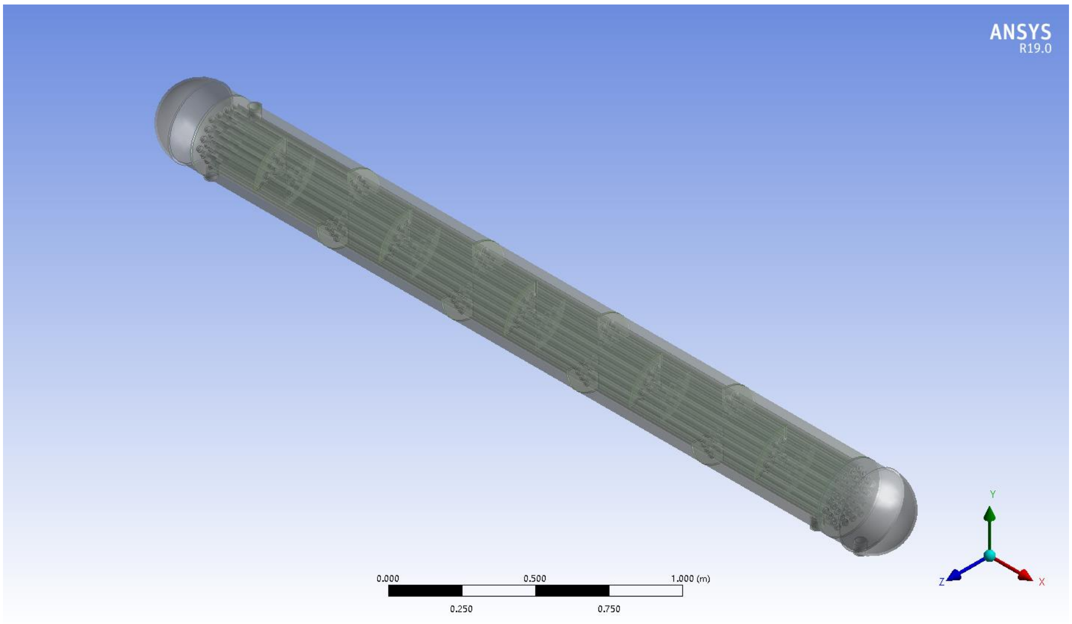

Figure 4. Three-dimensional model of shell-and-tube heat exchanger

This revision is incorporated in the text on Line 144.

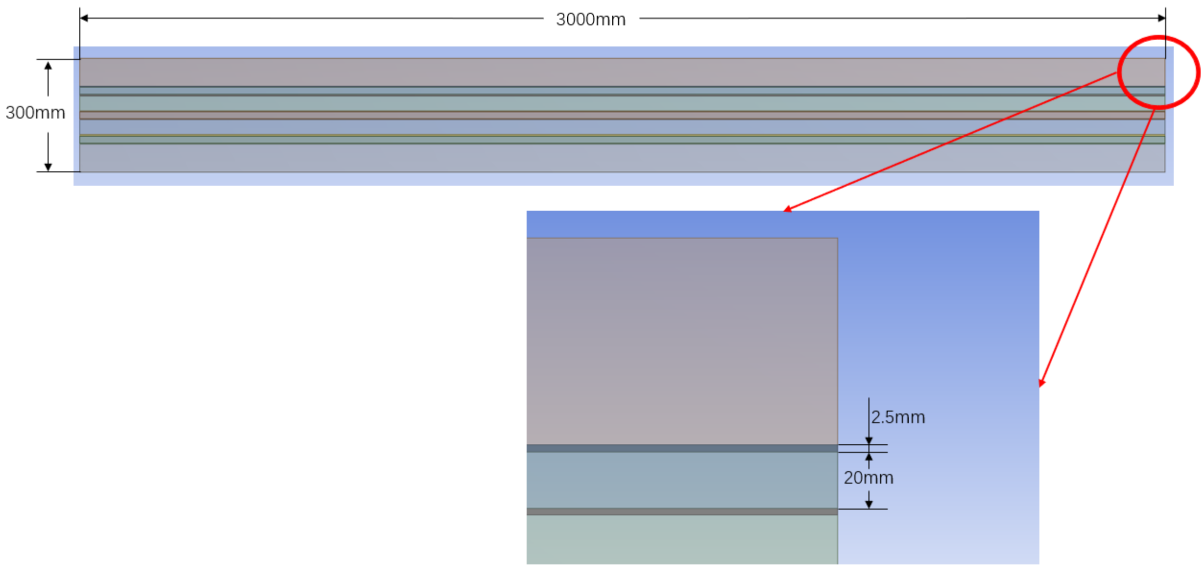

Figure5. Two-dimensional axisymmetric model of the heat exchanger.

This revision is incorporated in the text on Line 157.

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Point 5: The change of temperature has a great influence on the viscosity of fluid, but the author ignores the viscosity. How does the author consider it?

Response 5: Thank you very much for your question. Viscosity is an attribute of fluids, and different fluids have different viscosity values. The viscosity of the same fluid is significantly related to temperature, but almost independent of pressure. During the heat exchange process of high-pressure hydrogen in the shell-and-tube heat exchanger, as the inlet temperature of the high-pressure hydrogen increases, the average temperature on both sides of the cold and hot increases, and the viscosity of the gas increases with the increase in temperature[11,12], while the refrigerant The viscosity of R23 decreases with increasing temperature. Therefore, we made the following amendments to the article based on the reference.

Revise:

Therefore, as the temperature of high-pressure hydrogen increases, the average temperature on both sides of the cold and hot increases, the viscosity of the gas increases with the increase in temperature, and the viscosity of the refrigerant R23 decreases with the increase in temperature [28].

This revision is incorporated in the text on Line 366.

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Point 6: For numerical simulation, the number of grids will affect the simulation results, but the author did not do grid independence verification. The reliability of the simulation data obtained is questionable.

Response 6: Thank you for your valuable suggestion. We have verified the independence of the grid[6].

Revise:

The mesh check is performed for the model. For ensuring the grid independence, the temperature of the hot fluid at the output is determined and evaluated for various meshes[6]. Figure 7 illustrates the results of the mesh sensitivity analysis in this work. It can be seen that the output temperature of the hot liquid varies negligibly between the grid containing 2.82 × 105 and 3.24 × 105 cells. Thus, the grid with 2.82 × 105 cells is used for the simulations.

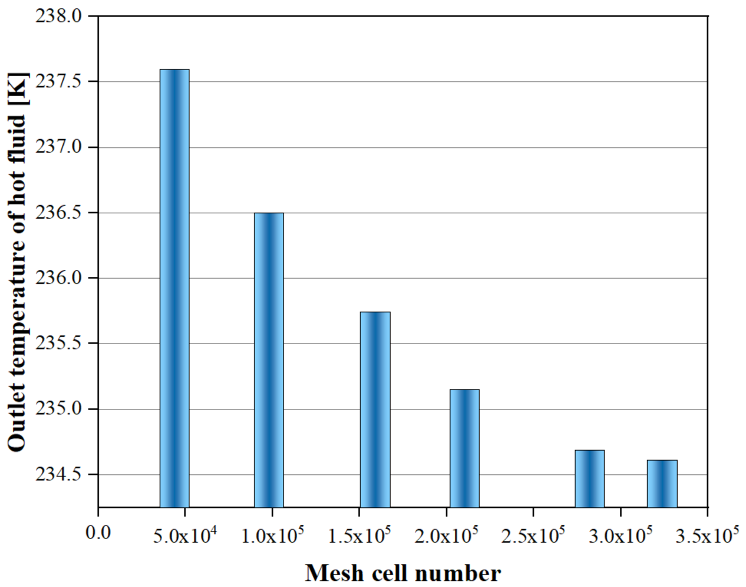

Figure 7. Results of the grid test for the exit temperature of the hot fluid versus the grid cell number.

This revision is incorporated in the text on Line 249.

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Point 7: The existence of baffle will make the shell side fluid deviate from the axial flow of the heat exchange tube, that is to say, the shell side fluid does not always flow along the axial horizontal flow of the heat exchange tube actually. However, the two-dimensional model simplified by the author just avoids this point. Is the applicability of this model reliable?

Response 7: Thank you very much for your question. The presence of the baffle will cause the shell side fluid to deviate from the axial flow of the heat exchange tube. However, in the heat exchange process, the horizontal flow of the refrigerant and the high-pressure hydrogen flow in the heat exchange tube counter currently conduct heat exchange[10]. In addition, according to the comparison between our simulation and the data in the literature, the error of the simulation results is small, so our simulation is suitable.

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Point 8: What does the vapor volume fraction in Figs. 8, 9 and 10 represent and how is it obtained need to be supplemented.

Response 8: Thank you very much for your question. The gas volume fractions in Figures 8, 9, and 10 represent the gas phase generated by the heat transfer of the refrigerant R23. During the simulation, the evaporation-condensation model was used to simulate the phase change of the refrigerant R23[13,14], and this process was analyzed after the end of the simulation. We have made the following supplementary explanations on the acquisition of the gas phase volume fraction.

Revise:

In the simulation, the evaporation-condensation model was used to simulate the phase change process of the refrigerant R23, and the gas phase volume fraction cloud diagram during the simulation process and the gas phase volume fraction of the shell-side basin with time change were obtained.

This revision is incorporated in the text on Line 299.

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Point 9: Why can't we see the obvious temperature change at the shell side from FIG. 6?

Response 9: Thank you very much for your question. In the process of heat exchange, the heating temperature of the refrigerant R23 increases, but the reason for the obvious temperature change in Fig. 6 is as follows. Refrigerant R23 will undergo a phase change when heated near the wall of the heat exchange tube[13]. Since the density of the gas phase is less than that of the liquid phase, the gas phase with a slightly higher temperature will stay away from the heat exchange tube. At the same time, the flow rate of the refrigerant is relatively large, and the higher temperature gas phase will enter the cooling cycle of the refrigeration system. Therefore, the temperature change on the shell side in Fig. 6 is not obvious.

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We appreciate your consideration of our revised manuscript for publication in processes. We hope that the revisions in the manuscript and our responses will be sufficient to make our manuscript suitable for its publication.

Once again, thank you very much for your suggestions and warm work. If you have any questions, please don't hesitate to contact me at the address below.

Thank you and best regards.

Yours sincerely,

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