NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

Whey Off Balance: Analyzing Processing Issues Using Mass Balances

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Part I – Whey Refinement

You have been hired by a national company in the dairy industry to be a process engineer on a whey processing line. As your first assignment, your supervisor wants you to do a mass balance on the entire process, since he suspects something is not going right. He tells you he can't find the specs on the flow rates for the process now, but if you come back tomorrow, he should have them. In the meantime, he wants you to check the flow rates on the process streams today.

Upon reaching the process area, you are greeted by a tangle of vessels, pipes, pumps, heat exchangers, and other processing equipment. You decide to ask an operator where the process starts to try to get your bearings. As the operator leads you to the start of the process, he proudly states that he was part of the original team that added on the whey refinement process. "It takes something that we used to have to pay to get rid of and turns it into money!" he exclaims. You find out from the operator that the whey filtration process produces lactose and whey protein concentrate, among other things.

Questions

1. Determine the major ingredients and products of a whey refinement process. Start with the basic ingredients for making Cheddar cheese, but focus on the whey refinement process, not the cheesemaking process. Several references are provided below if you are unfamiliar with whey refinement.
2. Based on your answer to Question 1 and the references provided to you, draw a block diagram to illustrate the flow of materials though the process. The block diagram need not be highly detailed, but should include the major steps of whey refinement.

References

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Part II – Mass Balance

With some help from the friendly operator, you sketch out a block diagram of the process in the control room (Figure 1). The control room displays some of the flow rates you need, so you scribble them down on the block diagram. The raw milk flow in is 128,000 gallons per day. Yesterday's total cheese production was 125,000 pounds. The flow rates of reverse osmosis permeate and concentrate are 72,000 gal/day and 60,000 gal/day, respectively. The ultrafilteration unit produces 42,000 gal/day of permeate; 13,000 of those gallons exit the process as concentrate from the evaporator.

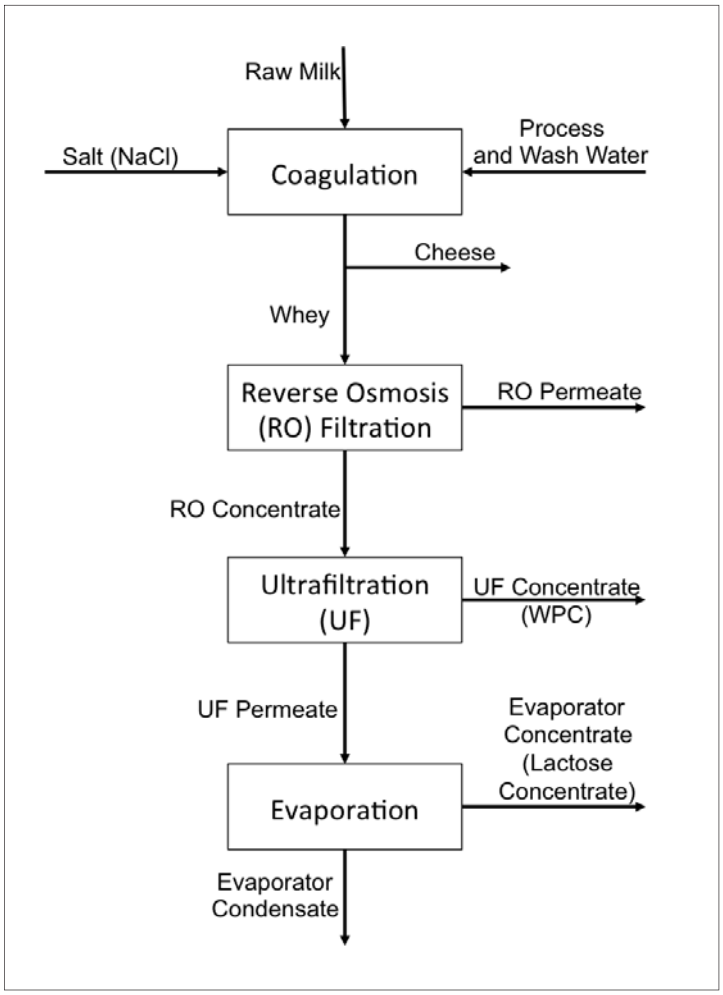

Figure 1. Block diagram for process line.

Questions

1. Perform a mass balance on as many of the units as you can. *(Note that you may not be able to complete some of the balances!)* Assume volumes are additive. What is the flow rate for each process stream?
2. Are there any flow rates for which you cannot solve? If so, list the streams.
3. Explain how you, as a process engineer, could determine the flow rate of a stream if you couldn't solve for it with the data you had.

Part III – Flow Rates

You stop by your supervisor's office the next day with your numbers. He hands you a copy of a process flow diagram with flow rates based on clean, fully-functional equipment (Figure 2).

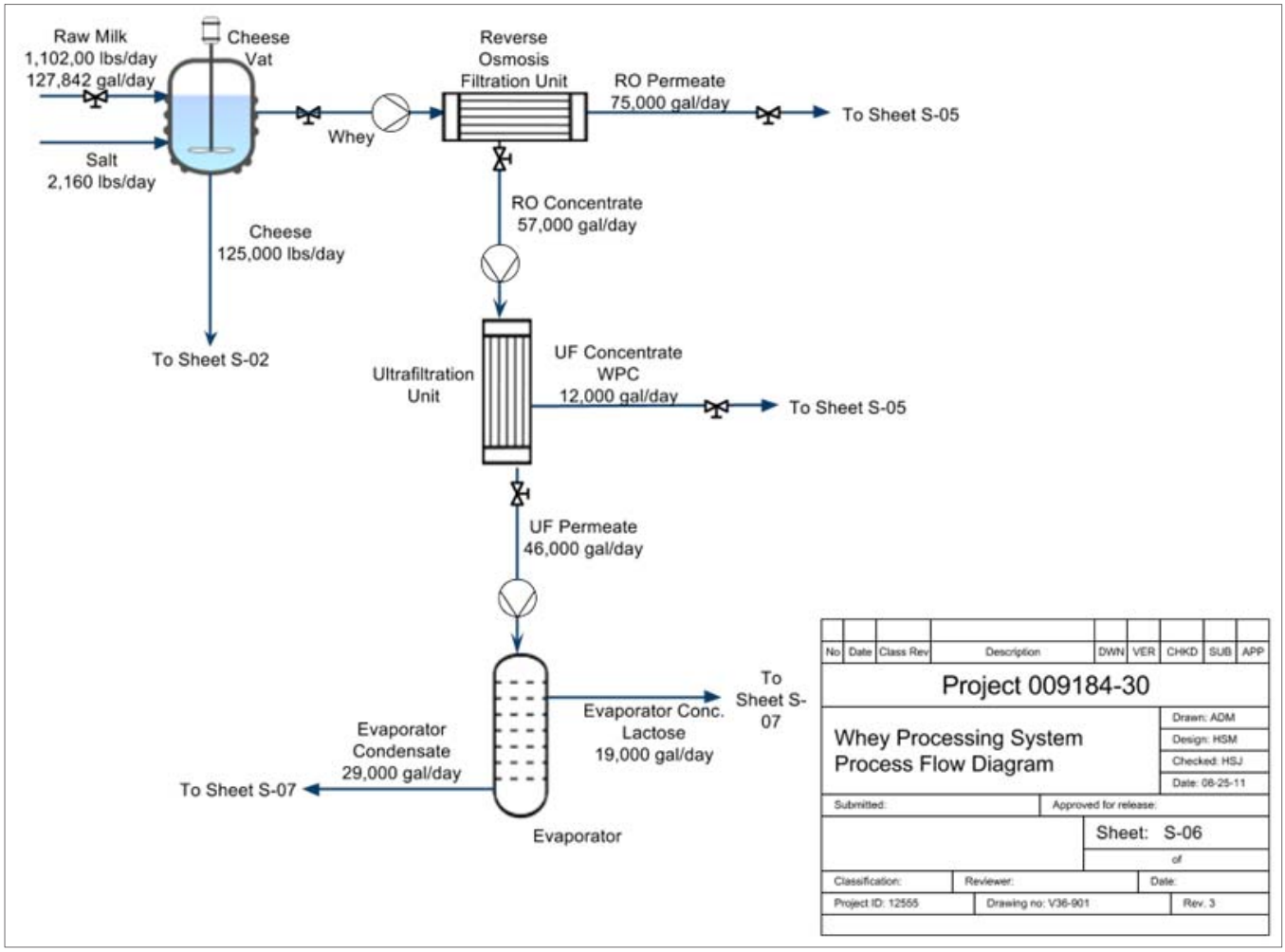

Figure 2. Theoretical flow rates for whey processing line.

Questions

1. Compare the actual flow rates to the theoretical flow rates. Identify any problem areas in the process.
2. Discuss possible causes for discrepancies in flow rates.
3. Discuss the product quality issues that can arise if the processing equipment is not working properly. Be sure to explain how and why the problems might occur.
4. Based on your analysis of the theoretical and actual flow rates, provide recommendations for process adjustments for your supervisor. When developing your answer, think about process parameters, such as pressure and temperature, and cleaning schedules. How might these be adjusted to improve the current process?