

## Lab #5 – Froth Flotation

Name: \_\_\_\_\_ Grade: \_\_\_\_\_

Feedback:

Group Name: \_\_\_\_\_

*Pledge: "On my honor as a Virginia Tech student, I have neither given nor received unauthorized assistance on this assignment." Initial\_\_\_\_\_*

**By participating in this class, all students agree to abide by the Virginia Tech Wellness principles:**

<https://ready.vt.edu/well.html>

If you answer yes to any questions in the Hokie Health survey (questions can be posted in the syllabus), you must not attend class in person. Notify me by email and contact Schiffert Health Center for testing and quarantine protocol.

### Introduction

Froth flotation is one of the most widely used methods of mineral separation in the field of mineral processing. Almost all sulfide minerals are treated by froth flotation, as well as many oxide minerals and industrial minerals. In this process, mineral particles that have an affinity for air, known as hydrophobic particles, selectively attach to air bubbles and are recovered in the froth at the surface of the flotation machine. Mineral particles that have an affinity for water, known as hydrophilic particles, remain in the pulp and are discharged with the tailings.

Froth flotation would not be possible without chemical additives, called reagents which are added to the feed pulp to aid and control the separation of various minerals. Several types of chemicals may be added including:

- **Collector**            A reagent that selectively makes one type of mineral particle hydrophobic, while leaving the other mineral particles unaffected.
- **Depressant**        A reagent that inhibits or prevents adsorption of a collector on a mineral and hence prevents its flotation.
- **Activator**            A reagent that enhances or assists the adsorption of a collector.
- **pH Modifier**        A reagent that changes the hydrogen ion concentration of the pulp, the purpose being to either increase or decrease the adsorption of a collector.
- **Frother**              A reagent that prevents the coalescence of bubbles and allows a stable froth to form on the surface of the flotation machine.



*Figure 1. Laboratory froth flotation machine.*

Xanthate and dithiophosphate are common collectors used in the flotation of sulfide minerals. These collectors adsorb on the surface to render minerals such as chalcopyrite hydrophobic.

The purpose of this lab is to determine the optimum separation point (i.e., copper grade, copper recovery, gangue rejection, and separation efficiency) for selectively floating the chalcopyrite away from the gangue minerals in the minus 100 mesh chalcopyrite ore. In order to determine the optimum separation point, a two-stage rougher-cleaner flotation circuit will be tested and the overall grade and recovery of the process will be determined. This exercise will require two weeks to complete (i.e., one week for experimental data collection and one week for calculations/plotting).

### Helpful Equations

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**Two Product Formula**     $Y = 100 \frac{(f - t)}{(c - t)}$

**Recovery**                     $R = 100 \frac{Cc}{Ff} = (100 Y) \frac{c}{f}$

**Rejection**                     $J = 100 \frac{Tt}{Ff} = (100 - Y) \frac{t}{f}$

**Separation Efficiency**     $SE = R_{\text{Valuable}} - R_{\text{Gangue}}$

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## Procedure

### Week 1 – Flotation Testing

1. Don all appropriate safety and personal protective equipment.
2. Obtain a sample of collector solution from your laboratory instructor. The solution was prepared by your instructor using the following steps.
  - a) Add 0.5 g of potassium amyl xanthate (PAX) to a 100 ml flask and fill the flask up to the 100 ml mark with water. Mix the flask until the PAX dissolves.
  - b) Add 0.5 ml of Aerofloat 238 (dithiophosphate) to a 100 ml flask and fill the flask up to the 100 ml mark with water. Mix the contents of the flask.
  - c) Use a graduated cylinder to measure 53 ml of the Aerofloat solution. Add this amount of Aerofloat solution to a flask containing all 100 ml of the PAX solution. This will be your collector solution.
3. Obtain a  $\approx$  500 gm sample of dry minus 100 mesh chalcopyrite ore from your instructor. (The sample is the fine product from the Bond grinding test you conducted in a previous exercise.)
4. Place the  $\approx$  500 gm ore sample in a 2-liter flotation cell. Mount the cell on the flotation machine and lower the agitator into place.
5. Fill the 2-liter flotation cell with tap water to a level  $\approx$  1 inch from the overflow lip of the cell. Turn the agitator on with the air valve closed and allow 30 seconds for the solids to fully wet.
6. Insert the pH probe into the slurry. Add sodium hydroxide until the pH of the slurry is approximately 10.5 to 11.5. Remove the pH probe.
7. Add 1 ml of collector solution and 2 drops of frother (MIBC) to the slurry. Allow the slurry to mix for about 30 seconds.

8. Place a pan under cell overflow lip and open the air valve completely. Use a froth paddle to manually remove the froth from the top of the cell for a period of approximately 3 minutes.
9. After 3 minutes, close the air valve and add 1 ml of collector. Allow the slurry to mix for another 30 seconds.
10. Open the air valve and float until the froth is depleted. The material contained in the pan at this point is the “Rougher Concentrate”.
11. Turn the agitator off, raise the agitator assembly and remove the cell from the machine. Pour the slurry contained in the cell into a bucket labeled “Rougher Tailings”. Use a rinse spray from a water bottle if necessary to ensure that all particles have been removed from the cell.
12. Remount the empty flotation cell back onto the flotation machine. Pour the “Rougher Concentrate” from the pan back into the flotation machine, lower the agitator back into place and refill the cell with tap water to within  $\approx$  1 inch from the top of the overflow lip.
13. Switch on the agitator, place a clean empty pan under the cell lip, and turn the air back on and continue to float until the froth is depleted. The product contained in the pan should be labeled as “Cleaner Concentrate” and the slurry remaining in the cell should be labeled as “Cleaner Tailings”.
14. Label three separate pieces of filter paper with the titles “Rougher Tailings”, “Cleaner Concentrate” and “Cleaner Tailings”. Weigh each piece of filter paper and record the values in column [2] of the data table provided below.
15. Filter the “Cleaner Concentrate” the appropriately labeled filter paper. After filtration is complete, place the filter paper and wet sample into a pan and place it into an oven to dry overnight. Repeat this procedure for both the “Cleaner Tailings” and “Rougher Tailings”.
16. After the three samples have completely dried, remove them from the oven and allow them to cool for a few minutes. Record the weights of the three samples and filters in column [3] of the data table. Calculate the dry weights present in each product by subtracting column [3] from column [2]. Record the results in column [4]. Calculate the weight percentages and record the values in column [5] (Hint: Check to make sure they sum to 100%).
17. Place the dried material from each stream in an appropriately labeled plastic sample bag. The label must include “Date”, “Group No.,” “Sample ID” and “Sample Weight.” Give all three bags to your instructor for the determination of the copper assay. Record the assay values in column [6] when they are provided back to you during the next laboratory period.

Week 2 – Flotation Data Analysis

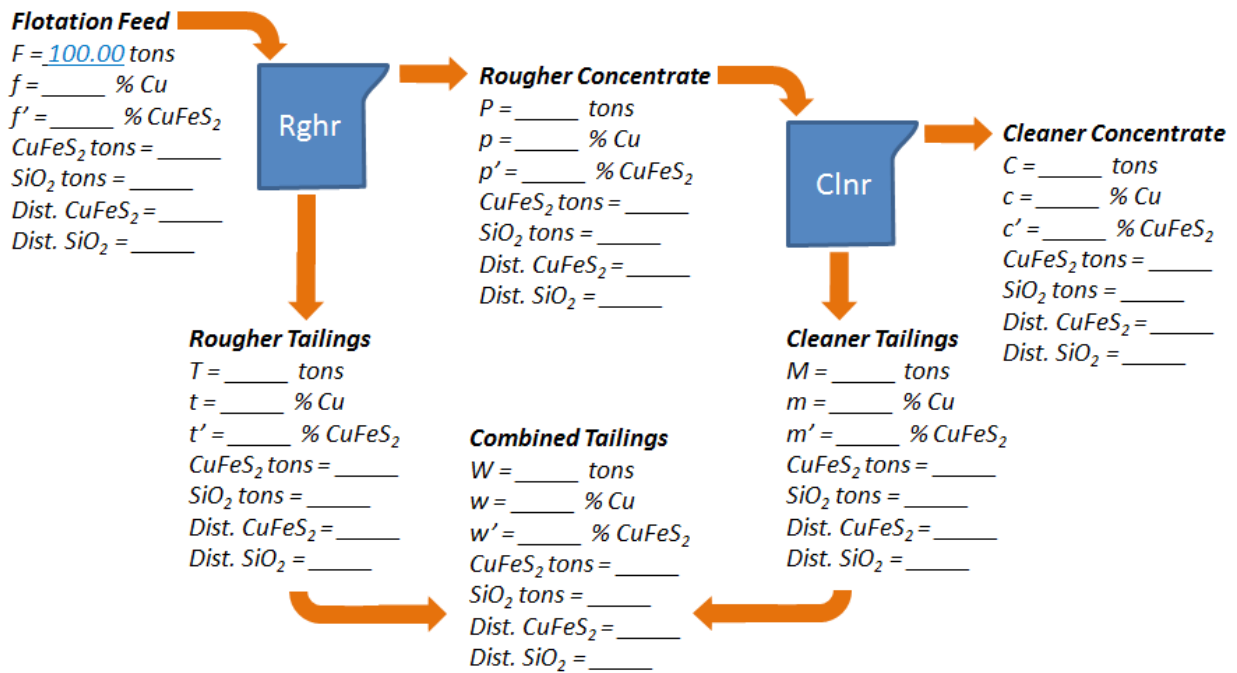
1. Use the weight percentages (column [5]) and assay values (column [6]) to complete the “Metallurgical Flowsheet” shown on the next page.
2. Use the values in the “Metallurgical Flowsheet” to complete the “Metallurgical Balance Sheet” shown on the next page. The “Distribution (%)” values represent the percentage of a given element or mineral in the feed that reports to a given product stream.
3. Enter the performance indicators for your test in the spaces provided. (Hint: “Recovery” is the “Distribution” of a desired element or mineral in a concentrate stream, while “Rejection” is the “Distribution” of an unwanted element or mineral in a tailings stream.)
4. Use the “Laboratory Summary Data Sheet” to enter the performance indicators from all other flotation tests conducted by different laboratory groups. (Hint: “Separation Efficiency” is defined as “CuFeS<sub>2</sub> Distribution” minus “SiO<sub>2</sub> Distribution” in a given product stream.)
5. Plot your test data and the data from all other groups on the graphs provided. Don’t forget to include end points for 0% and 100% whenever they make logical sense in terms of expected performance.
6. Based on your plots, estimate the copper grade, copper recovery, gangue rejection, and separation efficiency that one should achieve at the optimum separation efficiency.

**Data Records & Calculations**

Week 1 – Flotation Testing

[1]	[2]	[3]	[4]	[5]	[6]
Stream	Filter (gm)	Sample + Filter (gm)	Sample Weight (gm)	Sample Weight (%)	Assay Cu (%)
Cleaner Conc.					
Cleaner Tail					
Rougher Tail					
Feed	--	--		100.00	

Week 2 – Flotation Data Analysis



## Metallurgical Balance Sheet

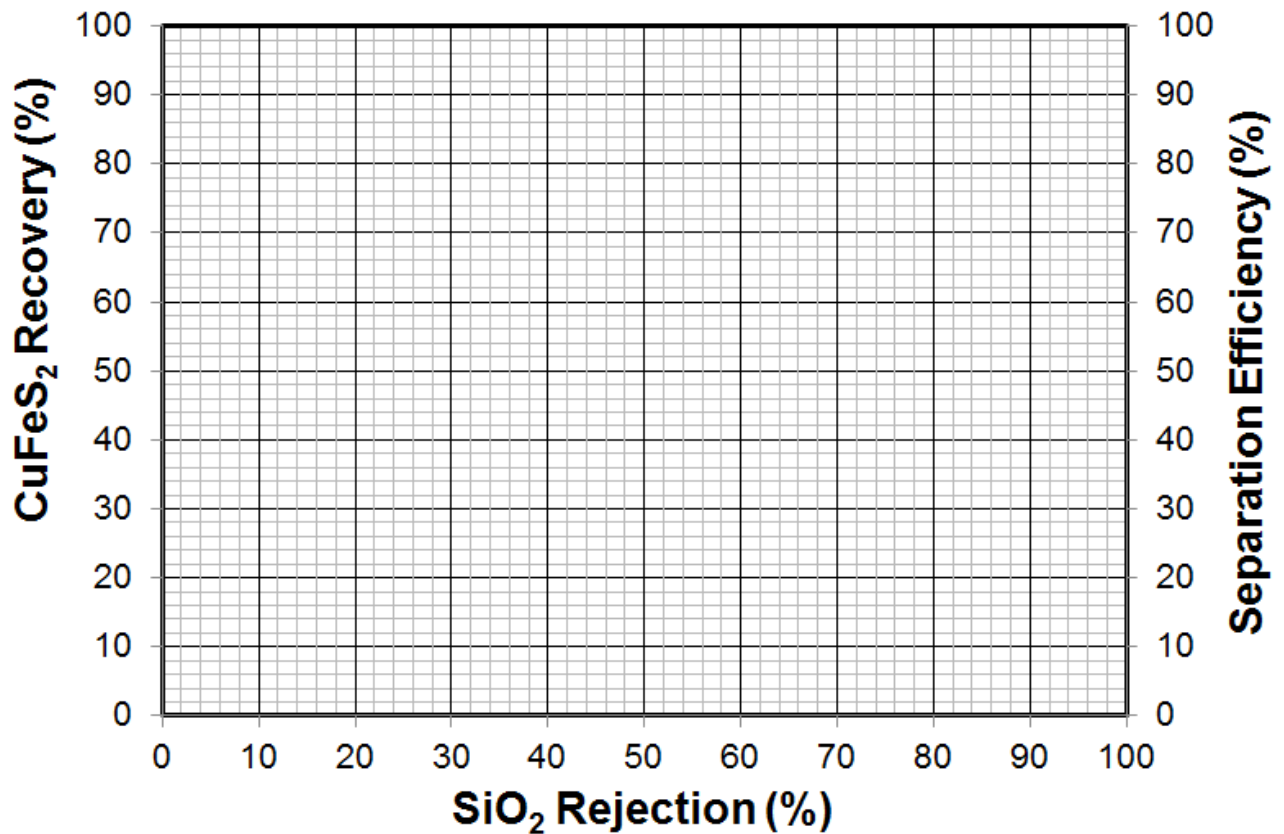
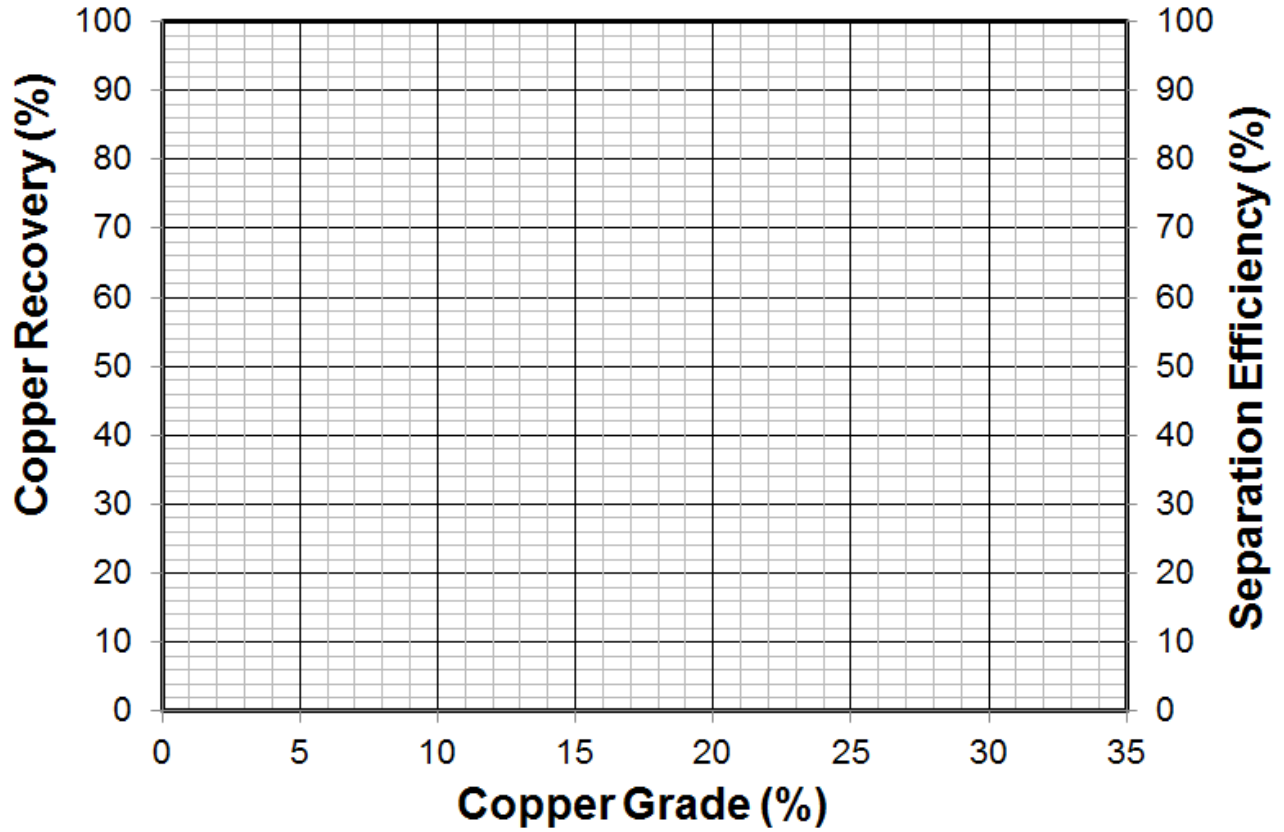
Stream	Weight (%)	Assay (%)			Distribution (%)		
		Cu	CuFeS <sub>2</sub>	SiO <sub>2</sub>	Cu	CuFeS <sub>2</sub>	SiO <sub>2</sub>
Clnr Conc.							
Clnr Tail							
Rghr Conc.							
Rghr Tail							
Feed	100.00				100.00	100.00	100.00

## Summary of Performance Indicators

Configuration	Assay Cu (%)	Cu Recovery (%)	CuFeS <sub>2</sub> Recovery (%)	SiO <sub>2</sub> Rejection (%)	Separation Efficiency (%)
Rougher Circuit					
Total Circuit					

## Laboratory Summary Data Sheet

Group No.	Product Stream	Assay Cu (%)	Cu Recovery (%)	SiO <sub>2</sub> Rejection (%)	Separation Efficiency (%)
1	Cleaner Concentrate				
	Rougher Concentrate				
2	Cleaner Concentrate				
	Rougher Concentrate				
3	Cleaner Concentrate				
	Rougher Concentrate				
4	Cleaner Concentrate				
	Rougher Concentrate				
5	Cleaner Concentrate				
	Rougher Concentrate				



## Discussion Questions

1. What is the optimum operation point for this separation? How did you arrive at this optimum?
2. Is the optimum a “technical optimum” or “economic optimum”? What’s the difference?
3. What operating point would you want to conduct this separation in an actual industrial plant? Why?
4. Many copper flotation plants achieve recoveries of 88-92% and grades over 30% copper. How does your results compare with these? What are some of the differences between your laboratory procedure and plant operations that might allow you to get a higher grade (or recovery)?

## Conclusions

1. What was the objective of this laboratory exercise?
2. What were your major findings?
3. What important fundamental concepts did you learn from the exercise?