Cleaning Water Analysis-Teacher Notes

A Solidify Understanding Task

Purpose: In this activity students will look at raw and graphed data from a beverage system cleaning to determine if the water consumption is efficient as defined by industry standards.

Career Field:
Data Analytics

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NC Math 4 Standards:
NC.M4.AF.4 Understand the properties and key features of piecewise functions.

- NC.M4.AF.4.1 Translate between algebraic and graphical representations of piecewise functions (linear, exponential, quadratic, polynomial, square root).
- NC.M4.AF.4.2 Construct piecewise functions to model a contextual situation.

Unit Alignment:
WTCC Math 171 Unit 1

Common Core State Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
4. Model with mathematics.
5. Use appropriate tools strategically.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Prerequisite Skills

- Previous Excel experience helpful but not required, graphing data in Excel
- Reading and interpreting data from a graph
- Dimensional Analysis
- Average rate of change
- Military time

Time Required

The time required to complete this activity is approximated as follows:

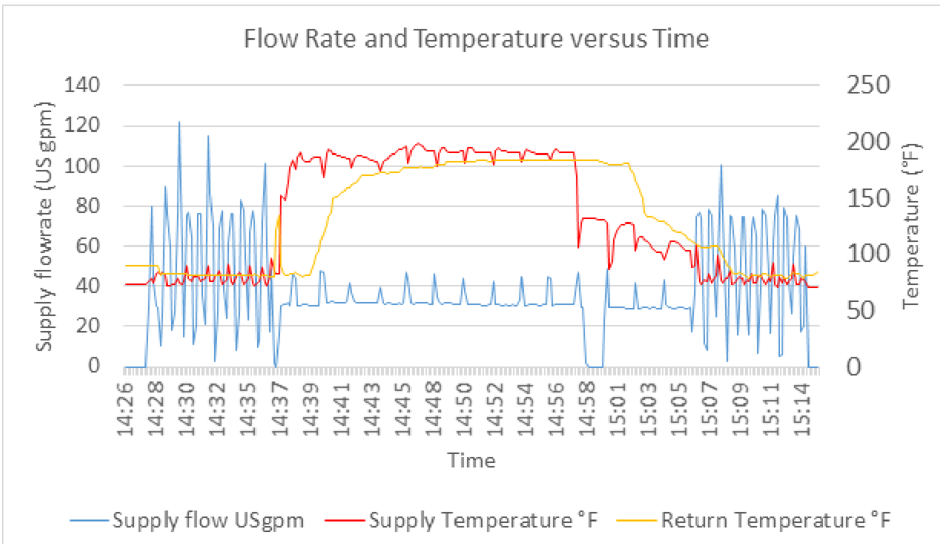
- Launch video - 5 minutes
- Desmos activity (can be assigned outside of class) - 30 minutes
- Activity parts 1-3 (can be used as a full activity) - 75 minutes
- Activity parts 4-6 (can be added separately or all together) - 60 minutes

Materials Needed

- Student Activity Sheet
- Excel data file
- Excel or google sheets

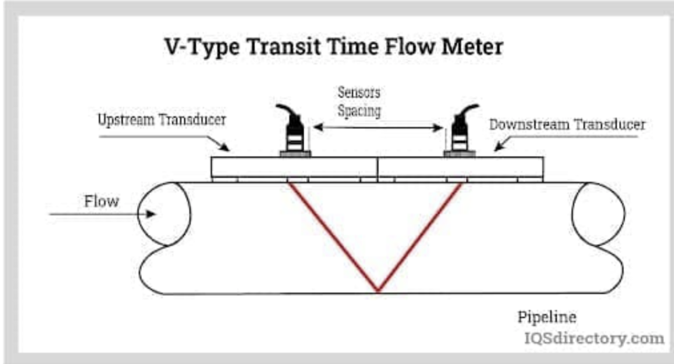
Notes about the data collection:

In this activity, there are 3 sets of data collected on this closed circuit beverage processing / cleaning system.



1. Supply water flow rate (gpm): This is a measurement of the flow rate of the water entering at the beginning of the circuit. It is important to note that the graph of this data shows 3 distinct sections that each pertain to one of the cleaning phases.

This data bounces up and down and this is a product of how the data is collected. Flow rate is measured with a clamp-on ultrasonic flow meter that sends and reads an ultrasound through the pipe wall. The transducers are mounted on the pipe which is completely filled with the fluid. The ultrasonic signals are emitted alternately by one transducer and received by the other. The flow rate is determined from the transit times of the ultrasonic signals.



For more information please see:
https://www.flexim.com/sites/default/files/2020-11/tsfluxus_g601st%20-%20en-gb.pdf

There can be anomalies in this data, like at 14:58 when the flow rate drops to 0. These are typically explained by process events and not necessary to explore for this activity.

2. Supply side water temperature (°F): This is a measurement of new water as it is entering the circuit. There are smaller fluctuations in this data, again due to the measurement device. It is important to note where this data first jumps up as this is the indication that the heated cleaning water (with soaps included) has entered the circuit and the cleaning phase is beginning. When the temperature begins to drop it is called the cool down (still part of the cleaning phase). At this time, new cold water is being pulsed into the system in bursts to begin to cool the system in preparation for the final rinse. The system could not support a direct change from the heated cleaning water to the cold final rinse water.

3. Return side water temperature (°F): This is a measurement of the water as it leaves the circuit. There is an anomaly data point around time 14:37. The first time the return water is heated is recorded around time 14:39, this is important because it is used to calculate the time and eventually the volume of one cycle of water through the entire circuit one time. There is a similar lag in the cool down phase and even at the beginning of the final rinse phase.

The Teaching Cycle:
Launch:
1. Assign the desmos activity outside of class before starting the activity.
2. Show the video in class.
3. Students read the introduction, the cleaning cycle, and the initial thought questions.
4. Students answer the initial thought questions and share answers in pairs, groups, or as a class.

Explore:
1. Students read the problem, then work parts 1 and 2.
   a. Pause in pairs, groups, or as a class to review the answers to these questions. For the numerical answers, they will be approximations (as read from the graphs) and do not have to be exactly the same.
2. Parts 3-6 all have a couple of pause and think questions at the beginning. For each part, students complete these and discuss answers in pairs, groups, or as a class before continuing on to the activity questions.

Discuss: While discussion is built into this activity through the initial thought, and pause and think questions, other discussion prompts upon completion are:

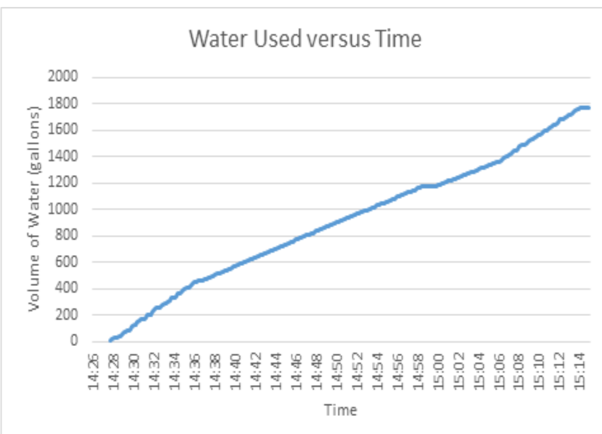
- Why could different students have similar but not the same answers from this activity?
  - What level of precision or accuracy do you think would be required for this procedure in industry?
- How do you think an industry standard like 3X circuit volume for rinse water or 5 ft/sec for velocity of rinse water is determined? Why might different systems need more or less than an industry standard value?

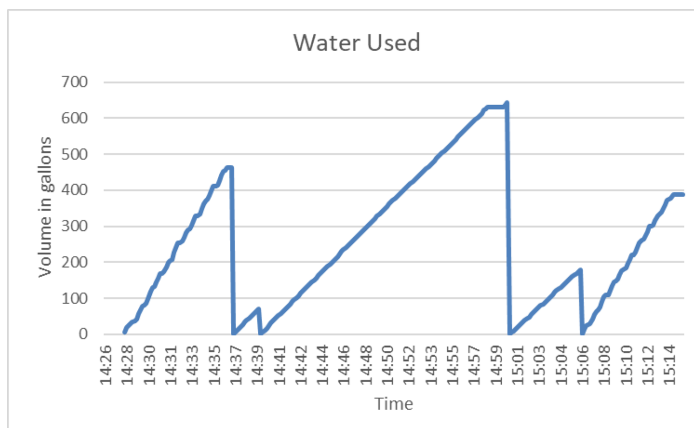
Exit Ticket:

1. Supply flow rate data is recorded every 20 secs on a closed circuit system. 2 consecutive data points of water flow rates are measured as 85 gpm and 92 gpm. What is the volume of water, in gallons, entering the circuit during this time?
   a. $\frac{85+92\ gallons}{1\ minute} * \frac{1\ min}{60\ sec} * \frac{20\ sec}{1} = 59\ gallons$

Two example assessments for testing:

1. If a 4 inch diameter pipe has water at a flow rate of 85 gpm, what is the velocity of the water in ft/sec?
   a. $\frac{85\ gallons}{1\ min} * \frac{1\ min}{60\ sec} * \frac{1\ ft^3}{7.48\ gallons} * \frac{1}{\pi*\left(\frac{4\ in}{2}\right)^2*\left(\frac{1\ ft}{12\ in}\right)^2} = 2.2\ \frac{ft}{sec}$
2. Examine each graph given below and answer the following questions for each graphic:





   a. In a complete sentence describe what the average rate of change means for the graph.
   b. Calculate the ARC with the initial and final data points and write a sentence that explains it.