Sample Needed Math Project Scenario

Award # 2100062

CIP Water Usage

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PROBLEM STATEMENT

A technician needs to use data gathered from a flow meter to maintain a consistent and repeatable clean in place (CIP) process to effectively and conservatively clean apparatus used in food and beverage processing industries.

SCENARIO DESCRIPTION–SPECIFIC EXAMPLE

Clean In Place (CIP) systems as shown below in figure 1, are used to internally clean tanks, hoses, and other apparatus used in the food and beverage commercial industry. The CIP system shown below consists of three tanks and a processing unit of PLC's that cut on and off the various tanks that are used for an interval of time during a cleaning. The initial phase is a rinse phase and all water from the rinse is sent to drain. The second phase is a cleaning phase that contains cleaning and sanitizing chemicals that get reused many times (not sent to drain). The third phase is the final rinse phase and all water from this rinse is sent to drain. Initially, specialists must gather and analyze data to determine the optimal level of cleaning and water usage that allows safe production and consumption as well as being good stewards of water usage. Technicians must then gather and analyze data to confirm the optimal level of water usage is consistently repeated. To collect flow data, a flow meter (shown below in figure 2) is strapped to the incoming pipe and sends an ultrasonic signal that bounces back (shown in figure 3) and records the fluid flow, as well as the fluid temperature. This data is collected and reported in a spreadsheet (as shown in figure) that can be analyzed to determine water usage. The full spreadsheet link appears below in the math questions.

Fig. 1

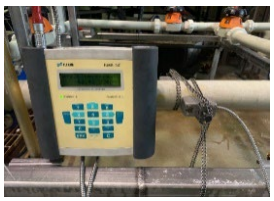

Fig. 2

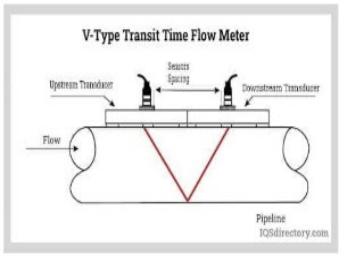

Fig. 3

	A	B	C	D
1		A	A	A
2		CIP supply flow	CIP Temp. supply	CIP Temp. return
3		USgpm	°F	°F
4	14:26	0.00	73.0	89.4
5	14:26	0.00	73.0	89.4
6	14:26	0.00	73.0	89.4
7	14:26	0.00	73.2	89.4
8	14:27	0.00	73.2	89.4

Fig. 4

ISSUES TO BE ADDRESSED

To initially determine the level of water usage in the initial rinse and final rinse stages, the circuit volume of water (total gallons needed to clean from start to end of one cleaning loop) needs to be determined to apply the industry standard target of no more than three times one circuit volume should go to drain. A circuit consist of many tanks and connecting pipelines. When cleaning, tanks are not filled but rather sprayed and partially filled. The dairy plant at NCSU can be viewed and explored in 3D at NCSU Dairy Facility (text: https://my.matterport.com/show/?m=ixyCZKJR1o1) to view the complexity of a cleaning circuit. To compute a circuit volume, the time difference between the heated water going into the circuit and the heated water coming out of the circuit is measured to determine the time for the water to travel once through the circuit. Also, measuring the flow rates and the time difference allows the circuit volume to be computed. Once the correct usage of water is determined, the CIP can be programmed to utilize each stage of the cleaning process for the optimal amount of time. Data collected from cleaning cycles can be used to monitor the cleaning process for repeatability. A technician can obtain the flow rates from

the flow meter and the time for the initial and final rinses, and then compute the volume of water going to drain. Testing each cleaning cycle with the design target can assure consistent cleaning processes that are safe for food and beverage production and consumption as well as being a good steward of water usage.

WHERE DOES MATHEMATICS COME IN?

Unit conversations, using rates to compute amounts, military time, working with spreadsheets (creating and analyzing graphs and entering formulas).

Math Questions:
Prior to answering the following questions, it is recommended to view the video https://www.youtube.com/watch?v=o_PQNz_rBRU&t=163s for an overview of the CIP process.

1. Create a line graph of the flow rates and time using the CIP DATA to determine:
   a) How many defined sections of this graph do you see?
   b) What explanation can you give for each section?
   c) How much time does each section account for?
2. Create a line graph of both temperatures and time using the CIP data to determine:
   a) At what approximate time does the supply water temperature begin to rise?
   b) At what approximate time does the return water temperature begin to rise?
   c) At what approximate time does the supply water temperature begin to drop?
   d) At what approximate time does the return water temperature begin to drop?
3. Using the CIP data, determine:
   a) At what time stamp and flow rate would you say the end of the initial rinse occurs?
   b) The total time of the initial rinse. (Highlight this section of data in a color)
   c) At what time stamp and flow rate would you say the end of the cleaning phase occurs?
   d) The total time of the cleaning phase. (Highlight this section of data in a new color)
   e) At what time stamp and flow rate would you say the end of the final rinse occurs?

f) The total time of the final rinse. (Highlight this section of data in a new color)

g) The total volume of water used in the initial rinse phase of the cleaning process.

h) The total volume of water used in the final rinse phase of the cleaning process.

i) The total amount of rinse water (initial and final) used in one full cleaning.

4. Using the CIP data, determine:

    a) The total volume in one circuit

    b) The industry standard (i.e. three times the circuit volume) amount that should be sent to drain.

    c) The amount of water sent to the drain in excess of the industry standard amount found above.

Teacher Resources:

Video that introduces Diversey, Barry Sperling's success story, and a contextual introduction to the design problem:

https://www.youtube.com/watch?v=o_PQNz_rBRU&t=163s

Teacher Desmos activity that contains pre-requisite math skills:

https://teacher.desmos.com/activitybuilder/custom/62deb948ace6830f5ec925fe

Schematic Drawing of NCSU Dairy Facility Tanks and Piping Network:

(red is the hot line, blue is the cold line, and green is the cleaning line)

https://drive.google.com/file/d/1Roq00tTJfKbQNA3-EUj4dYe2AWdbouXr/view?usp=drive_link