Dilution Plant Challenge Teacher Notes

Introduction

This PowerPoint resource has been designed to assist teachers in making the science curriculum relevant to students' everyday lives.

Suitable for use with **keystage 4 or 5** students, this 'ready to use' resource provides students with the opportunity to undertake a challenge which many Chemical Engineers working in industry face regularly, proving that the science learnt in the classroom is being used on a daily basis within the Chemical Engineering industry – simple dilution calculations can be the difference between profit and loss for multinational household name companies.

To support teachers, a comprehensive set of speaker's notes to support the PowerPoint slides is included.

Dilution Plant Challenge Speaker's Notes

Slide 1: Title Slide

Speaker's Notes: "This session is going to take us through the kinds of ideas and calculations a chemical engineer would have to think about when designing a real plant. Today's example is for a dilution plant. Lots of plants have this problem, in other words, a product is produced, perhaps from a reactor, but at the wrong concentration, so it has to be diluted to be the correct strength. A good example of this is in the food industry. When drinks are made they must be the right concentration – too strong and it tastes bad, too weak and people will not drink the product"

Slide 2: The Design Requirements

Speaker's Notes: "So, you are all chemical engineers, and you have been asked to design a system to dilute a product from a reactor. The concentration must be 20% in water, and have a pH equal to 5. Being given numbers to design to is known as the "specification" or "spec". It is important to make sure that the equipment is designed to produce the product in accordance with the "spec" otherwise the product will not be right and we cannot sell it."

Slide 3: Diluting a product

Speaker's Notes: "A nice way to think about a full scale chemical process is to think about how you would dilute the product in the chemistry lab. If you were to dilute a chemical, firstly you would put it in a beaker. This is fine if you want to dilute 100g of a chemical, but what would you do if you wanted to dilute thousands of tonnes? Chemical engineers use vessels or reactors to do this. These are large metal containers designed specifically for the particular chemicals that will be used in them"

Slide 4: Picture of Vessel

Speaker's Notes: "Now we are going to make a drawing of all the pieces of equipment we will need, starting with our vessel. This is drawing, when it is finished is know as a flowsheet. It shows symbols to represent all the equipment that will be needed to dilute the chemical and how it all works. This is the symbol for a vessel"

Slide 5: What next?

Speakers Notes: "If we were in the lab, we would put our chemical in the flask and add water to it, however it is not so easy in a large plant. Can you imagine trying to add thousands of tonnes of water into the top of a vessel? So what do we do? Well, we continuously add the water and the chemical into the vessel, it's like continually pouring our reagents into a giant flask. To do that we use pipes."

Slide 6:

Speaker's Notes: We show the pipes we need on the flowsheet by drawing lines and labelling with which reagent will flow through them, either chemical or water"

Slide 7: The Next Step....

Speakers Notes: "In the lab we would give our mixture a stir to make sure everything is well combined. In industry it is very important to make sure that everything is well mixed because the vessels are so large if we didn't mix then we would probably find that we didn't get the right concentration. We use a giant stirrer"

Slide 8:

Speaker's Notes: "We are beginning to build our design. We now have pipes to help us put or reagents into our vessel, and a stirrer to mix them together."

Slide 9: There's something missing....

Speaker's Notes: "So, going back to how we might do this the lab, we would have a beaker full of diluted chemical. We then might pour it into a bottle to store it. What would we do with a large quantity? Well, we need another pipe! This one takes the product (dilute chemical) to a storage tank. This is known as the product line"

Slide 10:

Speaker's Notes: "This is shown on the drawing like this"

Slide 11: Checking our product

Speaker's Notes: "In the lab we would check that we had made the right product. Remember our specification? We need it to have pH of 5. We might use litmus paper to test this. On a real plant we would use an analyser. This is a clever piece of equipment that takes a small sample of the product which is the product line and tests it to see if it is the correct pH. But what would we do if it is wrong? We would be sending huge amounts of product to our storage tank which doesn't meet our specification and we would then have to dispose of it because we couldn't sell it. This is very wasteful"

Slide 12: Quality checking

Speaker's Notes: "Using an analyser to check our product is the right pH is known as checking the quality. If it is not pH=5 then we want to stop it going to the tank. Stopping the product is known as "tripping the plant" this is when the plant stops working and shuts down safely because something has gone wrong with it."

Slide 13:

Speaker's Notes: "We are going to add our analyser and "trip" to our drawing. Chemical Engineers have a special way of showing how a trip works on their drawings. You can see a circle with QI in it. The Q stands for quality and the I stands for indicator. So this tells all the engineers that there is an analyser which shows you what the pH is. Next to that there is a circle with QAH in it. Again, the Q stands for quality, the A stands for alarm and the H stands for High. So this tells the engineers that an alarm will sound in the control room if the pH of our product starts to go high. This will allow the engineers to go and investigate and see if anything has gone wrong. The last circle has QAHH written in it and this represents the trip. Again, Q means quality, a means alarm and H means high. The fact that 2 h's are shown means that an alarm will sound and the plant will automatically shutdown because the pH has gone too high."

Slide 14: Our design!

Speaker's Notes: "This is our flowsheet" Our design is almost finished. The flowsheets shows the equipment we need and how our feedstocks (water and chemical) enter the vessel and how the mixture leaves the vessel. Now we need to know how big to build our vessel and pipes. This depends on how much we want to make. We work this out by doing a mass balance…"

Slide 15: The First Rule of Chem Eng

Speaker's Notes: "The whole of chemical engineering is based on a rule… What goes in must come out… This is just like the theory of conservation of mass and energy, you cannot cerate it or destroy it you can only transfer it from one type to another."

Slide 16:

Speaker's Notes: "Here is our flowsheet with some numbers on it. Remember our specification? We need 20% of our chemical in water. So 1 part chemical to every 4 parts water. Lets say that we want to have 1000 litres per hour of our diluted chemical product to go to our storage tank. How much water will we need per hour and how much chemical?"

Slide 17: The calculation…

1 part chemical + 4 parts Water = 5 parts in total

We need 1000 litres per hour of diluted product = 5 parts.

So X = Chemical flow = (1/5) x 1000 = 200 litres per hour.

And Y = water flow must equal the amount of flow left over (conservation of mass, if it goes in it must come out!) = 1000 – 200 = 800 litres per hour.

Slide 18:

Speaker's Notes: "Here is our flowsheet with our numbers on it"

Slide 19: Our plant is taking shape!

Speaker's Notes: "this is the first few steps of designing a real plant! What would a chemical engineer do next? Using the same principles they would work out how big the vessel needed to be, how big the pipes needed to be and add valves. Valves are like taps which allow you to turn the flow of the reactants on and off if you wish."

"To make a plant a reality the design which the chemical engineer does gets passed to other types of engineers, so they can do the design of more specialised pieces of equipment such as the control systems, electrical systems and the foundations of the buildings."

Slide 20: Other jobs for chemical engineers on a project

Speaker's Notes: "Chemical Engineers have lots of different jobs, not just designing a plant:

- **Selling a plant to a customer –** these engineers know all about business and how to make a plant make money
- **Initial design –** These engineers come up with the initial ideas for a new type of plant
- **Detailed design** – these engineers take the initial idea and add all the detail to make it work

- **Safety –** These engineers make sure that the plant is safe for everyone to work on.
- **Commissioning –** These engineers start-up new plants and make sure they are working properly
- **Operation –** These engineers are responsible for managing the running of the plant and ensuring that enough product is made and that it matches the specification