TBP01x - 2.7 - banana 4

Welcome to banana number 4, which is about gas phase calculations. So the big banana is that FN,in in mol gas per hour, is not equal to FN,out, so the gas which leaves the fermenter. Many people make the error by just forgetting about this and just saying that FN,in = FN,out and this leads to very large errors in conclusions. So let me take an example again. So here we have the broth, and here we have a gas phase, and basically we are interested in oxygen consumption, so what is the Ro¬, in mol oxygen per hour. And I explained to you in previous units that for that we need to do gas phase measurements, so what do we have, we have here a gas phase in of 1000 moles of gas per hour, and this is a special gas because it contains 20% oxygen and 80% nitrogen and 0% carbon dioxide. And then of course here we have the organisms, and they produce carbon dioxide and they consume oxygen. And so the other measurements is that we here measured 19% oxygen and 5% carbon dioxide. Now from the broth, suppose that there is no in and outflow, so basically we know that RO is equal to and opposite to TN,o , so this comes from the broth oxygen balance. So that tells you we are interested in this here, so that means we are now going to calculate TN,o, and that comes from gas oxygen balance. And this is all steady state, so now we can write the oxygen balance. Basically we do it first in the wrong fashion by assuming this. So that means at steady state, the accumulation term is zero, we have an inflow 1000 moles per hour of gas with 20% oxygen so multiplied with 0.20. Of course we have an outflow, and there we assume now 1000 mol of gas per hour, because we are not aware of this yet, and we multiply that with 19% oxygen, and of course there is also then the disappearance of oxygen in moles per hour. So this would tell us that Ro is basically –TN,o and if we do the calculation, this is basically 200, so –TN,o is -200, plus 190, so this is -10 mol oxygen per hour. Now, my point is here we did a very grave mistake, so this is a wrong result. So what is now the proper result: that we recognize that FN,out, is not the inflow of 1000 mol per hour, the gas flow. So how do we get our FN,out? We discussed that before, so we need to set up the nitrogen gas balance. Steady state means 0 is the nitrogen inflow here, that is very clear 80% multiplied by 1000, so that is 1000 multiplied with 0.80. And then we have of course a nitrogen outflow, because there is no nitrogen consumption here in the broth, so the TN is absent, so that means we only have an outflow and an inflow. And the outflow is the unknown FN,out multiplied by the nitrogen fraction, the mole fraction in the off-gas, which is of course 1-0.19-0.05, that's the nitrogen mole fraction. This gives you FN,out as a value which is 1052.63 mol per hour. So this is now 1052.63 mol of gas per hour. And this is calculated from a balance. And now we can make a proper oxygen balance, so now we say oxygen balance is: zero equals, still the same amount going in 1000 times 20%, 1000 times 0.20, minus what's going out, 1052.63 multiplied now of course with 19 % oxygen, 0.19 and of course there is transfer, minus TN,o and now we can calculate TN,o. What comes out now is that this one is zero mole oxygen per hour. So the end conclusion is that we were interested in R¬o, mol oxygen per hour. When we did the wrong calculation, so by not accepting this here, we came to the conclusion that we had 10 mole oxygen per hour consumed. When we do the proper calculation, by recognizing that this is not the same, so we see that the outflow is 5% higher than the inflow, then we calculate from the gas phase balances that there is no oxygen consumption at all. Which is a drastically different conclusion. So to try to give you a final understanding, this oxygen balance calculation is always very sensitive to this FN,in not equal to FN,out , why is that? Because you see that the oxygen balance has the following structure: there is a large inflow, in this case 200 coming in, but there is also here a large outflow 190, so that means that the oxygen which disappears is the difference of two large numbers. And when there is a small error of only 5% in this outflow, this translates very effectively in a very wrong calculation of the transported amount of oxygen, respectively the consumed amount of oxygen. So I hope this brings to you the message: never assume this, always use the nitrogen gas phase balance to calculate FN,out from FN,in.