Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems
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Lecture - 31
Practice Problem

Good morning everyone, welcome to part 2 of lecture 3 under module 8. If you recall our discussion of the previous lecture, we practice few examples on the gasification system. So, in this lecture as well, we will practice few more example based on the commercial system.

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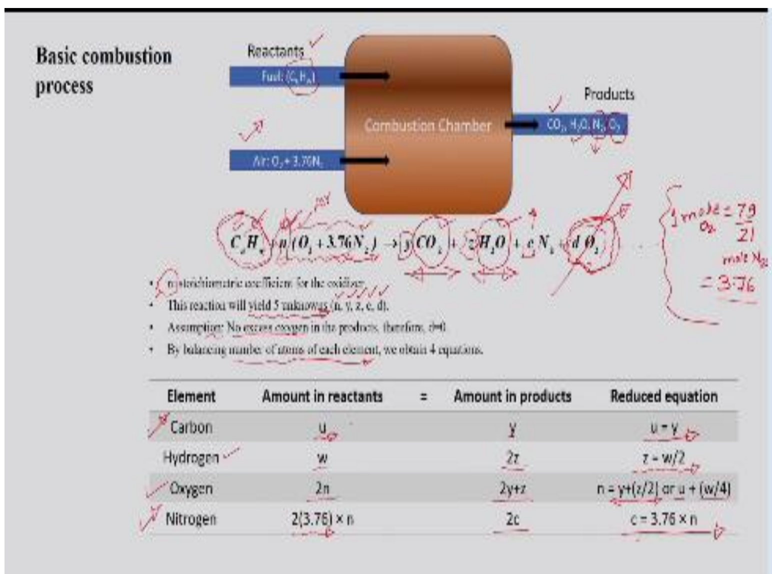

So, the basic conversion process is described by fuel and the oxidizer. So, fuel and oxidizer are the reactant in the system. In this process, the reactant and oxidizer undergoes chemical reaction and form completely oxidized product in the form of CO 2 and H 2 O along with it also releases certain amount of heat and the product form from this particular process are in the form of CO 2, H 2 O and the nitrogen.

The nitrogen here in this case is not participating in the reaction and the oxygen which can see here is the excess oxygen which is coming out from the chamber in case, if the excess air is supplied for the combustion process. So, now, if you consider hydrocarbon fuel in the form of, say, here C u and H w. So, now, we need to find out the amount of air which is required for the complete combustion of this fuel.

So, that it produces completely oxidized product in the form of CO_2 and H_2O along with the nitrogen that has been discussed, the nitrogen is not participating in the reaction, but if there is certain excess oxygen is supplied at the beginning of the combustion reaction, then the excess oxygen which is not taking part into the combustion process will be released along with the product.

However, when the fuel undergoes the complete combustion in the process, so, it completely oxidized the fuel to produce CO_2 and H_2O as a product, so, that we refer to as the stoichiometrically balance equation for the completely combusted fuel, but in practice, it may not be so, because along with the CO_2 and H_2O, it may form certain amount of CO_2 that is carbon monoxide and hydrocarbon which is not taking part into the reaction or in the combustion process, we also get released along with the product gas and nitrogen and oxygen.

If the oxygen is in excess and as I said the nitrogen is not taking part into the process of the commercial. So, it will come out as it is but in practice and nitrogen will also lead to a certain amount of product that is in the form of NOx like N_2O, NO_2 like that. So, under ideal condition, the combustion process mainly produces completely combusted product in the form of CO_2 and H_2O and are considered as a stable oxidized product of the fuel.

However, as I said in case of actual condition, maybe when the reaction is not following the stoichiometric path, so, in that case certain excess amount of oxygen is required to completely burn the fuel to produce the product, but once it is actual condition and excess oxygen is or the oxidizer is supplied for the reaction to takes place. So, basically it will lead to a certain more product along with the product which are shown here in the equation.

However, once we know the oxidizer and the nature of the oxidizer, so, we need to find out the amount of air or oxidizer is required to completely burn the fuel in the form of hydrocarbon. So, the hydrocarbon may be in the form of CH_4, C_2S_6, C_3H_x. So, this C_u may be 1, 2, 3 or this w may 4, 6, 8. Accordingly the specific hydrocarbon will be represented in the example. So, once this hydrocarbon is considered for the combustion process, so, we need to find out the amount of oxidizer or how much amount of air is required to completely burn this fuel.

So, that we can get completely oxidized product in the form of CO_2 and H_2O. So, for example, if you consider here that n is stoichiometric coefficient for the oxidizer that means, here this n represents the number of moles of oxidizer required for the reaction to takes place. So, if you tried to balance this equation here now, so, these represent the hydrocarbon fuel and envelope oxidizer is required to completely burn this fuel to produce y mole of CO_2 and z mole of H_2O along with it.

It is producing c because c here is why we are representing it as a here c, this n is still unknown to us and 3.76 nitrogen, which is a part of the air, because if you recollect our discussion in the commercial process, as we said, the one mole of oxygen is accompanied by 79 by 21 mole of. So, this is one mole of oxygen and it is accompanied by 79 by 21 moles of nitrogen. So, if we just try to do this calculation, it gives 3.76 moles of nitrogen.

In this case, as we are considering the air mixture, so, the air contains oxygen and nitrogen and the percentage of oxygen in the air is 21% and nitrogen is in the 79%. So, one mole of oxygen is accompanied by 79 by 21 that is 3.76 molar of nitrogen. So, it is very simple equation to balance also. So, we can balance it and you can just see whether we are getting these 3.76 as a number. So, this 3.76 is the number of moles of nitrogen, which are accompanied by the one mole of oxygen.

So, as we need to find out this n, so, n into 3.76, we are represented in the form of c here, so, that many moles of nitrogen will come out from the combustion chamber at the end of the process along with that, here it represents the d mole oxygen that means the amount of oxygen which is coming out with the product gas. So, this will be there only when we consider the excess oxidizer or excess air percentage in the air fuel mixture.

If it is stoichiometrically balanced, then this particular term may not be there in the equation. Whereas, if it is an excess air, it is mentioned in the problem that the excess air is supplied for the combustion to takes place, then certain amount of oxygen will come out in the product gas. So, once we consider these now, you can see that there are 5 unknowns in this particular equation, which is stoichiometrically balanced equation based on the unknown.

So, these unknown in the form of n, y, z, c and d this unknown need to be estimated. So, that we can find out the exact stoichiometric balance of the equation. So, these known once we estimate then we can put this unknown in the equation back and it gives us the stoichiometrically balanced equation for the combination of the hydrocarbon as the fuel. So, in this case, the assumption is no excess oxygen in the product.

So, as I mentioned, if it is a stoichiometrically balanced equation that is called as a even though theoretically balanced equation that means the theoretical air which is required for the combustion accordingly, if you try to balance the equation, in that case, the excess oxygen will not come in the product. And that is what is the meaning of this assumption here.

And by balancing the number of atoms of each element, so, we can get another 4 equation in the form of if you try to balance in the form of carbon, hydrogen, oxygen and nitrogen. So, we will get another 4 equations. So, with help of the 4 equation and this one equation which is main equation, we will have 5 unknowns and 5 equations, with help of that you can calculate the number of unknowns automatically.

So, this table which represents the how to calculate the number of atoms of specifically made, which are taking part into the reaction. So, first let us see the balance in the form of carbon atom. So, the element here we are considered is a carbon. So, in the reactor this particular hydrocarbon is represented as C u H w. So, here carbon is u, because we are considering the one mole of hydrocarbon fuel in this case.

So, u amount of the carbon is there in the reactor and when it is reacting, it is producing y because here also there is only one c’s. So, it is represented as y that is nothing but equal to u equal to y. So, the carbon is balanced in this particular equation accordingly. Now, if you just try to balance the H, that is a hydrogen so, in the reactant, so, this is w amount of H is available in the reactor, when it is getting oxidized, it is producing to z that is 2 hydrogens are there in the product gas. So, as a result 2 into z.

So, once you try to equate this, the z equal to w by 2. So, it is very simple how to do this particular balancing here. So, now, let us see the oxygen. So, in case of oxygen here as we are considering this as a air, so it is accompanied by the 3.76 moles of the nitrogen. So, this n represents the total moles of air required for the combustion process. So, the oxygen in this case is 2 into n. So, we will have 2 n in the reactant.

And then if you try to see the oxygen in the product, so we will have 2 y plus z. There is a one oxygen in the water as well. So, if we just try to equate this, we will get the n in the form of y plus z by 2, which is in the one form we can represent or again we can represent in the form of hydrocarbon fuel like u and w. So, you just replace u and z from the above equation here. So, you will get u plus w by 4.

Accordingly, we can balance this number of atom of the element in the equation. Now, the nitrogen as I said, it is not participating in the reaction, but still we need to balance it because it all depends on the number of moles of air, which is used for the combustion process. So, the nitrogen if you see in this case, it is 2 nitrogen into 3.76 moles of nitrogen, which is accompanied by the oxygen and then n number of moles of air which is required for the combustion process.

So, we are multiplying it by n. So, the amount in the product is c because as I said, we are representing in the form of c, because we do not know the n right now. So, this is 2 into c, so that is 2 c. Now, if you just equate these 2 equations, we will get the equation in the form of c equal to 3.76 n. So, this is how we can balance the number of atoms of each element in the combustion reaction and the stoichiometric equation as well.

Accordingly, we can also balance this equation if the excess air is used for the combustion process. However, there will be a slight changes in the values, but we can also balance a process where the excess air is used for the combustion process. So, now, once we understand the concept of the combustion process, let us try to solve one example considering the hydrocarbon as a fuel.

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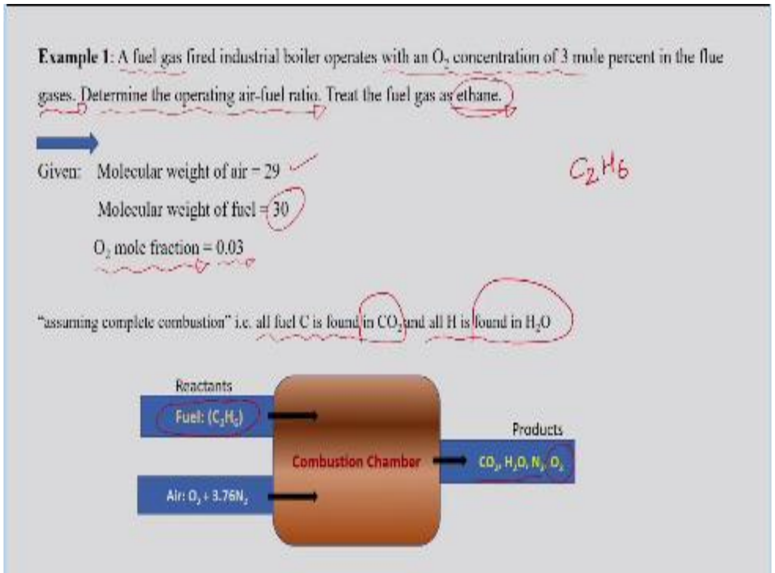

So, the hydrocarbon which is used in this example is ethane. So, a fuel gas fired industrial boiler, it operates with an O 2 concentration of 3 mole percent in the flue gases. So, it represents that 3 mole percent of O 2 is coming out in the product gas. This is what is the meaning of this sentence here. And based on this, we need to determine the operating air to fuel ratio. And in this case, the fuel is treated as ethane.

So, ethane in the senses like C 2 H 6, so, this is the ethane as a fuel, which is used for the combustion process in the boiler to produce the stable compound in the form of CO 2 and H 2 O along with that, it also releases certain amount of heat from the combustion process. So, in this case, the molecular weight of air is considered as 29 and the molecular weight of the fuel is 30 and the mole fraction of oxygen in the raw gas is 3% that is 0.03.

Now, assuming a complete combustion process, so, in that case, all the fuel is found in the form of CO 2 in the product and all H is found in the form of H 2 O in the product along with that, it has 3 mole percent of the oxygen in the product gas as well. But in this case, while balancing the equation, we are considering it as a complete combustion is taking place so, that apart from CO 2 and H 2 O, there is no other gases getting formed in the product gas like CO or you can say NO 2 or N 2 O.

It is a complete combustion process, where it is only giving CO 2 and H 2 O as a product, but certain amount of oxygen is also present in the product gas that is in the 3 mole percent. So, now, we need to find out the amount of oxidizer is required to burn this fuel in the combustion chamber. So, that it will release CO 2, H 2 O, nitrogen and oxygen as a product from the combustion process as there is a 3 moles of oxygen is present in the fuel gas.

So, now, let us balance this equation considering the theoretical air which is supplied for the specific reaction.

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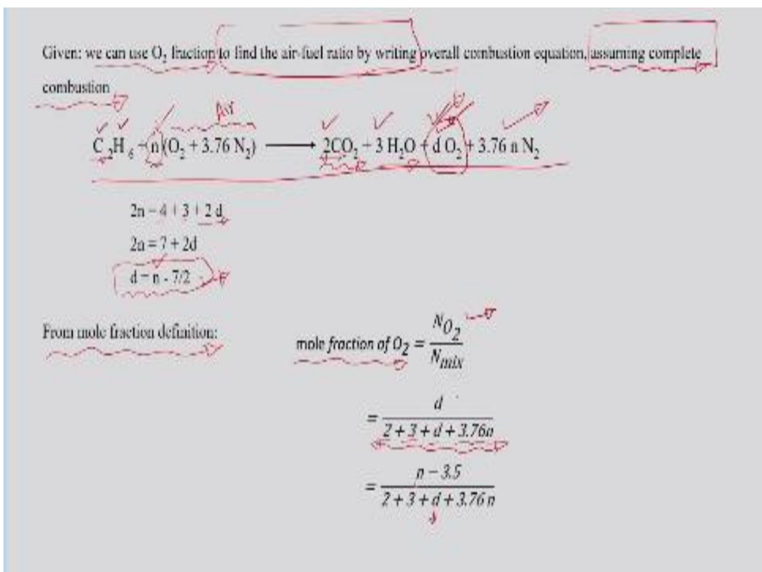

So, now from the given data, we can use the O 2 fraction to find out the air to fuel ratio just by writing the overall combustion equation for the specific field that is C 2 H 6 and in this case, the assumption is like the complete combustion of the fuel is taking place in the combustion process. So, let us see here this is C 2 H 6 which is taking part into the combustion process and these represent here the air.

So, the amount of air which is required for the complete combustion of this hydrocarbon fuel that we need to find out and it gives CO 2, H 2 O as a product of the combustion process. As we said, it is a complete combustion process. So, it is producing CO 2 and H 2 O as a product along with that it is also releasing oxygen in the flue gas as given in the problem 3 mole percent of oxygen is present in the flue gas. So, as a result, we have mentioned the oxygen in the balance equation as well.

And this is the nitrogen which is not participating in the reaction as it is a complete combustion process. So, now, in this case if you see there are 2 c, so, here also we have 2 c in the product 6 H, so, 3 into 2, so, 6 H in the product as well. So, the carbon and hydrogen it got balanced here in the product gas. Now, we have to just balance the oxygen. So, that you can find out the number of moles of air required for the oxidation purpose in the combustion process.

So, in this case, if you see it is a 2 n, this is 2 n equal to now, the oxygen in the product is like 2 into 2 that is there are 2 oxygen here. So, 2 into 2 is 4 and there are 3 oxygen in the water also. So, 4 plus 3 and we have 2 oxygen here that is 2 into d. So, it gives us the oxygen balance. Now, if you just solve this equation, we get in the form of d equal to n minus 7 by 2. So, this is d equal to n minus 7 by 2 that means, this much moles of oxygen is coming out in the product gas.

So, now, based on these, if you just try to find out the number of moles of air required for the combustion process, so, for that reason, we can write down the equation in the form of mole fraction of oxygen. Why? Because we know some mole fraction of oxygen in the product gas, so, by using that value, we can calculate the n that means the number of moles of air required for the combustion process.

So, how to do that? Say, mole fraction of oxygen can be written in the form of number of moles of oxygen in the product gas divided by the total mixture of gases in the product. So, as we know this is d here, according to this stoichiometric equation. So, this is d in the product gas. So, this we are written here and then the mixture is consist of 2 moles of CO 2, 3 moles of H 2 O, d moles of oxygen here and 3.76 into n moles of nitrogen in the product gas mixture.

So, these represent the total number of moles in the mixture and this represents the number of moles of oxygen. So, this gives us the mole fraction of oxygen. Now, d, if you can substitute this value of d from this equation here, it is n minus 3.5. Similarly, if you can substitute this d value here again in the form of n minus 3.5, so, the entire equation is in the form of n and we know the mole fraction of oxygen in the product gas.

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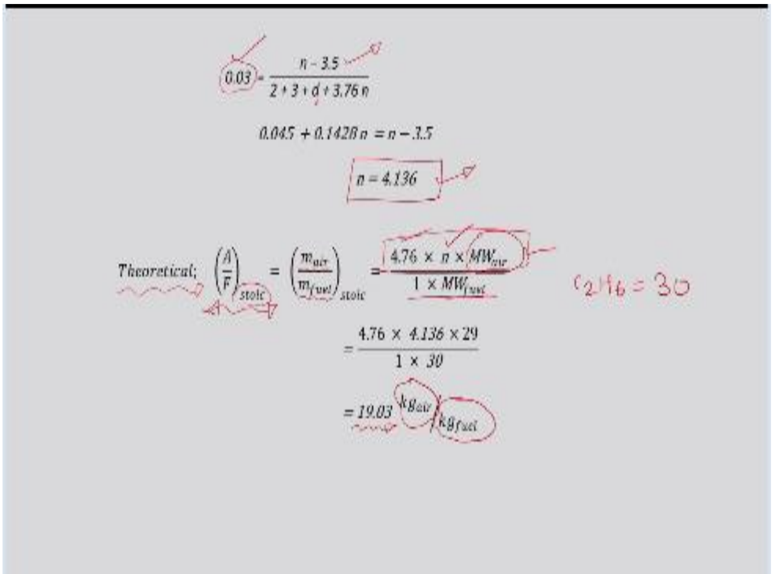

So, let us try to substitute these values and try to find out the n. So, this is 3 mole percent in the product gas that is a 0.03 fraction mole fraction. So, this indicates the mole fraction of oxygen in the product gas. We will replace this d here in the form of n minus 3.5. And again after replacing these d here also in the form of n minus 3.5. So, after replacing these, the n is the only unknown in this equation, and after rearranging this term, we get the value of n as 4.136.

So, now, it indicates 4.136 mole of air is required to burn the ethane in the combustion chamber that is C 2 H 6 in the combustion chamber. So, now, based on this value, we can also calculate the theoretical air to fuel ratio which is required for the combustion process. Theoretically in the senses like as we are considering here, it is a complete combustion process. So, the exact amount of oxygen which is required for the combustion to takes place can be calculated from this equation here.

And we know this equation as we already discussed about the air to fuel ratio and how to calculate the air to fuel ratio in the earlier lecture that is related to the combustion process. So, it is also represented as the theoretical or the stoichiometric air to fuel ratio which is required for the combustion to takes place in the combustion process. So, air to fuel ratio that is stoichiometric amount is equal to the mass of air, which is required for the combustion process divided by the mass of the fuel which is required to complete the combustion process.

And this is in this stoichiometric amount that means the exact amount of the oxygen or air which is required for the complete combustion of the hydrocarbon fuel, which gives CO_2 and H_2O as a product and this is represented as the mass of air is in the form of 4.76 that is one mole of oxygen plus 3.76 moles of nitrogen and this indicates the number of moles of the air which is required for the combustion process.

And once you multiply this mole by the molecular weight, you will get the mass of the air which is required. So, this value indicates the mass of air which is required for the combustion process divided by the mass of the fuel. So, as we consider the one mole of the fuel is taking part in the reaction to produce the CO_2 and H_2O as stable or combustible product. So, one mole of fuel and its molecular weight. So, it is a C_2H_6, its molecular weight is 30.

So, 1 into 30 gives the mass of the fuel according to the stoichiometric equation. So, once you calculate this value, it comes out in the range of 19.03 that is kilogram of air which is required per kilogram of fuel for the complete combustion of the hydrocarbon fuel that is C_2H_6 to produce CO_2 and H_2O as a product along with 3 mole percent of oxygen and nitrogen which is coming out as it is without participating in the reaction.

So, accordingly for any given fuel, we can calculate the air to fuel ratio as well as the number of moles of oxygen which is required or you can say the number of moles of air required or the number of moles of oxidizer which are required for the burning process. So, the fuel can be in the form of any hydrocarbon fuel like CH_4, C_2H_6, C_3H_6 as I mentioned earlier as well.

So, any such fuel can be used and you can practice such examples to find out the stoichiometric amount of oxygen which is required for the combustion process. And based on that you can also calculate the air to fuel ratio for the given field.

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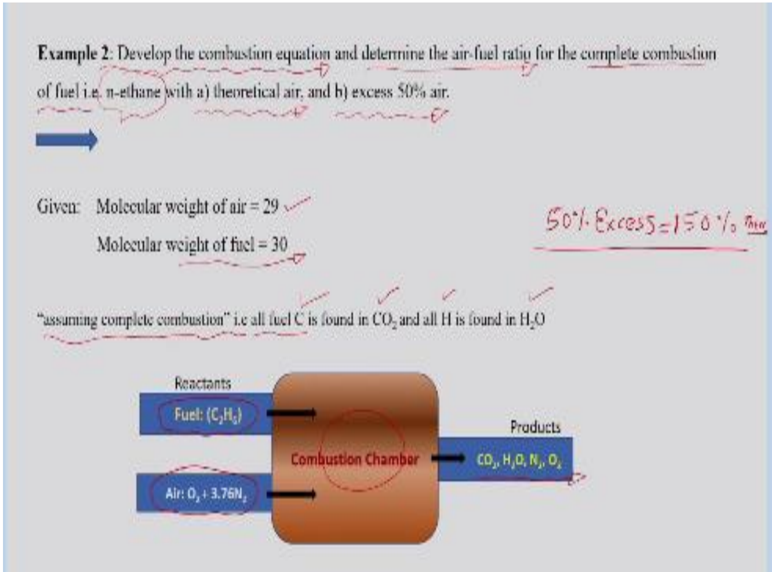

In the similar line, if you just try to solve another example, let us see the example here. So, in this case, we need to develop a combustion equation first and we need to determine the air to fuel ratio for again the complete combustion of fuel. So, in this case also the fuel given is ethane. But, in that case, we need to do the problem using theoretical air and in the second case, we need to consider 50% excess air is supplied for the combustion to takes place.

So, likewise, there are 2 examples we need to solve in this. One is considering the theoretical air which is required for the combustion process. And another case is considering the 50% excess of the theoretical air. So, that means 150% of the theoretical air. So, this is called as a excess air. So, this is a theoretical air which is required for the combustion process. So, in this case again the molecular weight of the air is considered as 29 because, again we are considering here as the air as the oxidizer molecular of the fuel is again the fuel is same is 30.

So, now, assuming the complete combustion again the assumption is same in this example as well. All fuels C is found in the form of CO 2 in the product and all H in the fuel is found in the form of H 2 O in the product. So, now, consider the same fuel again here, so, the fuel is ethane and air in the form of again O 2 plus 3.76 nitrogen undergoing a complete combustion process here and producing this range of the product that is CO 2, H 2 O, N 2 and O 2. So, the first case is theoretical air which is required for the combustion process.

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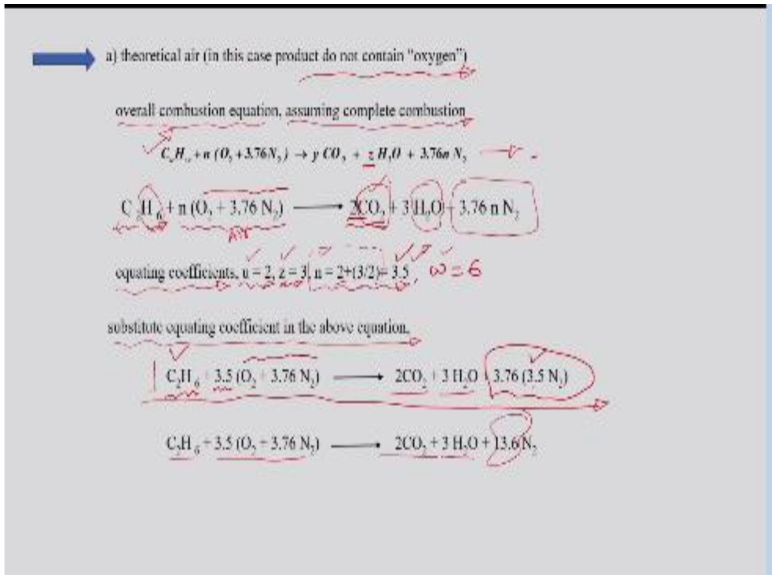

So, as we know the theoretical air in this case, the product do not contain the oxygen that is what is the meaning of the theoretical air which is required for the combustion process. So, now, based on that if you see the overall combustion equation assuming the complete combustion process that we are already returning the first slide itself it is in the form of this equation. So, which indicates the complete combustion of the hydrocarbon fuel to produce H 2 O and CO 2 as a product. So, this represents the complete combustion process.

Now, we are just representing the equation in the form of ethane that is C 2 H 6. So, C 2 H 6, this is a fuel which undergoes a combustion with this much moles of air as we presume the CO 2 and H 2 O as a product. So, you can balance the C and H 2 in the reaction. So, this to C as the product is coming CO 2, so, we have 2 CO 2. The C is getting balanced here and C here the H is H 6. So, in that case 3 H 2 O because we know already the product in the form of H 2 O.

So, simply if you write here the three, so, 6 H is getting balanced here, similarly, as we know the productive CO 2, so the 2 C are getting balanced in the reactant as well accordingly. So now, on the basis of this, as it is said, it is a theoretical air which is required for the combustion process. So, on the basis of that, will have 3.76 into n nitrogen in the product, but there is no oxygen here, because it is a stoichiometrically balanced equation where no excess air is required for the combustion process.

Or the other way the theoretical air which is required for the combustion process is used to balance the equation. So, as a result, there is no oxygen in the product gas. So, in this case, if you just equating the coefficient in the form of for example, u. So, u is equal to 2 in this case, we are just equating this coefficient here, and w is equal to 6, we can write here the w equal to 6 and then z.

So z, if you see here, this must be moles of water that means z equal to 3 and the number of moles of air, so, number of moles of air. If you remember the table, which is nothing but in the form of 2, 2 plus 3 by 2 equal to 3.5. So, this for example, in the table in this case, I am just taking you back to the slide. So, I am talking about this table here, that is in the form of y plus z by 2, so n is equal to y plus z by 2, or u plus w by 4.

So, once we equate this coefficient, so here, the n is nothing but y plus z by 2, so the y here is 2, z here is 3, so 3 by 2, the equation is in the form of 3.5. So, it gives n equal to 3.5. Clear. So now, by creating this equation, we got the value of u, z, n and w as well. So, now, once you know this coefficient, we can substitute this coefficient in the above equation, so, we will get the equation in the form of C 2 H 6 and n is equal to 3.5. So, the 3.5 is here.

And this is air as I mentioned earlier, this represents the air and it gives 2 moles of Co 2, 3 moles of H 2 O and 3.76 into n again the n is here 3.5 moles of nitrogen. So, this indicates the stoichiometrically balanced equation for the specific given hydrocarbon. And here, the hydrocarbon is considered as one mole of the hydrocarbon which is used for the combustion process.

Now, based on this, if you just simplify the equation, it will be in the form of like this and it gives around 13.6 moles of nitrogen in the product gas.

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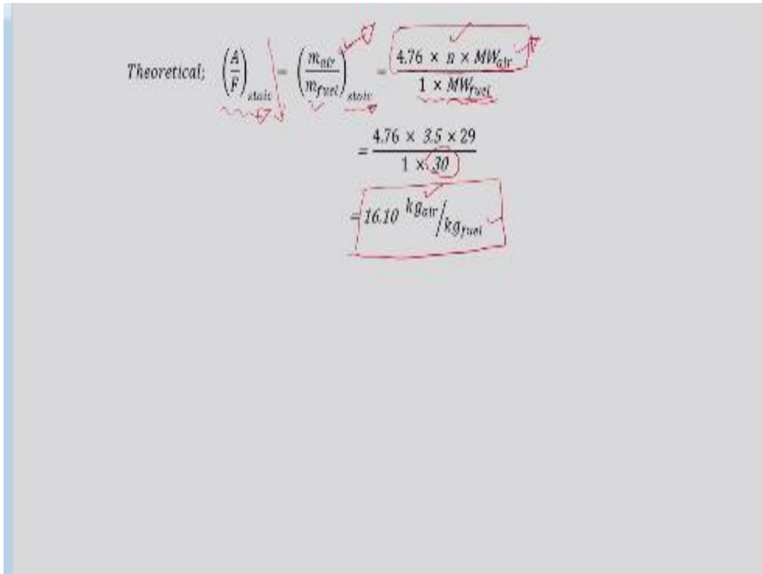

So, once we balanced this equation, we can easily calculate the theoretical air to fuel ratio required for the combustion process. The given fuel is C 2 H 6. So now, the theoretical air to fuel ratio is represented in the form of mass of air divided by the mass of fuel and this is a stoichiometric amount that is a theoretical amount which is required for the complete conversion of the fuel.

And the mass of air as we already calculated in the previous example, can be represented in this form, it is 4.76 into number of moles of air require for the combustion process multiplied by the mass of air. So, the mass of air in this case is 29, which I assume at the beginning itself and then the molecular weight of air is 29, which are already assumed in the previous case and divided by the mass of that means one into molecular weight of the fuel and here the molecular weight of the fuel is again the same that is 30.

So, once you do this calculation, we will get the equation in the form of this and the value is coming out around 16.10 kilogram of air required for the kilogram of fuel. So, this gives us the air to fuel ratio which is required for the combustion of ethane as a gas using air as the oxidizer in the combustion chamber. So, this is the air to fuel ratio, which is a theoretical air to ratio which is required for the combustion of the ethane in the combustion chamber.

So, the another question in the problem is, if the 50% excess air is supplied for the combustion process, then how to find out the amount of air which is required for the combustion process.

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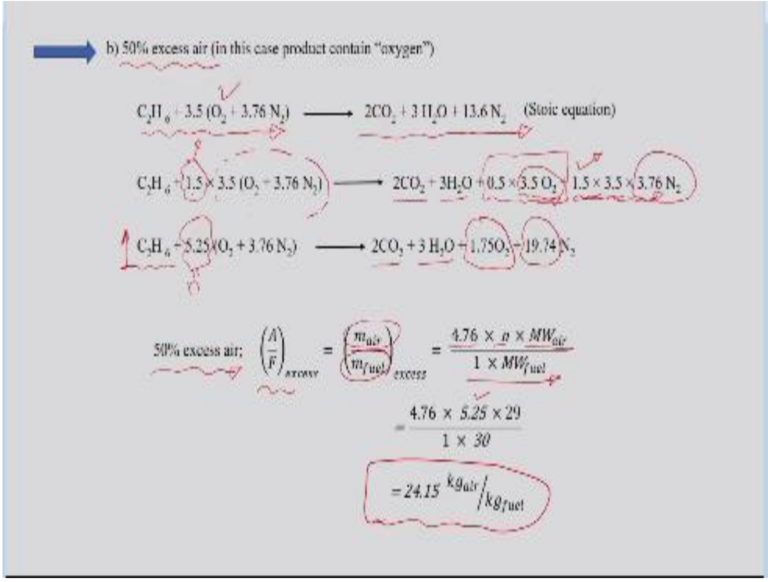

So, now, let us consider again the same concept that in this case the 50% excess air is used for the combustion to takes place. Now, after balancing the equation using the theoretical amount of air which is required for the combustion process, we got the equation in the form of this, which represented the stoichiometric amount of air which is required for the combustion process. So, now, in this case as the 50% excess air is used for the combustion process to take place.

So, it is just simply multiplied by 1.5 because it is 150% of the theoretical air which is required for the combustion process. So, here that is why we are multiplying it simply by 1.5 because the 50% excess air equivalent to 150% theoretical air, so, it is 1.5 times the theoretical air which is required for the combustion process. Now, once we balance this equation, it gives CO 2 and H 2 O as a stable product because it is a complete combustion again.

And this represents the amount of oxygen which is coming out in the produce gas, it is 0.5 into 3.5 into O 2. Why it is so? Because when you are saying, it is a complete combustion, so, theoretical oxygen which is supplied in the previous equation will be used to produce CO 2 and H 2 O whereas, the 50% excess air which is supplied for the combustion process will be coming out in the form of 0.5 into 3.5 moles of oxygen and 1.5 into 3.5, 3.76 moles of nitrogen.

In this case, it is coming out 1.5 because, as we said the nitrogen is not participating in the reaction. So, this entire value represents the number of moles of nitrogen coming out from the combustion process. Now, once you calculate these values, we will get the equation in the form of C 2 H 6 and it represents the n that is the number of moles of air required for the combustion process. It gives 2 moles of CO 2, 3 moles of H 2 O and 1.75 moles of oxygen is coming out as a product in the flue gas and these represent the total most of nitrogen in the flue gas.

Now, based on this, if you calculate the air to fuel ratio, that is 50% excess air when it is supplied and based on that if you just tried to calculate the air to fuel ratio, again it is a mass of air divided by the mass of air. Whereas in this case, now, it is 4.76 into n and the molecular weight of air. So, then we can convert these moles into molecular weight of air, divide by the n, same, because here again we are considering the one mole of hydrocarbons fuel is taking part into the combustion process and n here is 5.25 as I mentioned, remaining quantities are known.

Once you calculate this, it comes in the form of 24.1 kilogram of air per kilogram of fuel. So, from this 2 ratio, one which we have calculated using the theoretical air which is supplied for the combustion process and one with 50% excess air, we can see like how this air to fuel ratio is changing here. So, this is giving the value in the form of 24.15. Whereas in the earlier case, it was 16.10 because it is the exact amount of oxygen or the oxidizer, which is used for the combustion process.

Whereas in this case, it is 50% excess of the theoretical amount that is why it is called as a 50% access means 150 percent of the theoretical amount which is required for the combustion process. So, as a result, even the air to fuel ratio will also get affected. Once you understand the example, which are in the form of complete combustion using the theoretical air which is required for the combustion process or when it is supplied with the excess air to complete the combustion process, we can calculate the air to fuel ratio accordingly.

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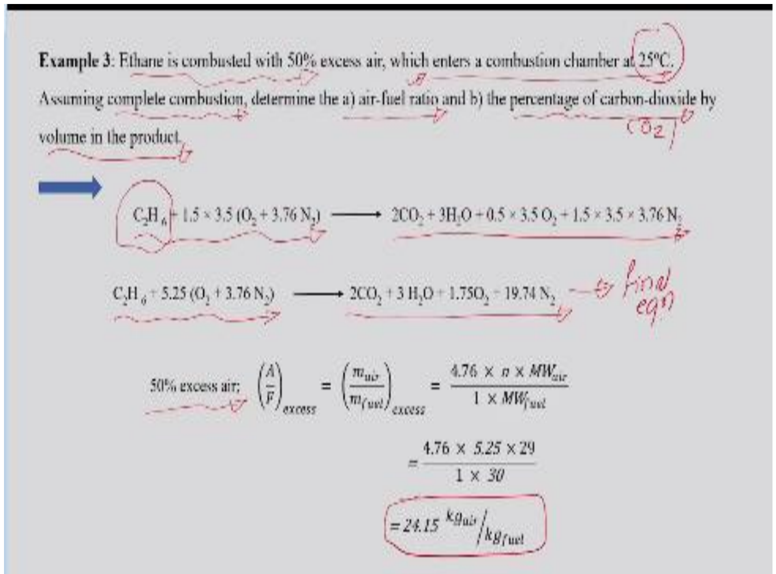

Let us try to solve another example in that we can calculate even the percentage of specific substance in the product gas either it can be a carbon dioxide, it can be one H 2 O or even it can be oxygen also. So, we will try to solve one such example, where we have been asked to estimate the percentage of carbon dioxide in the product gas.

So, what is the percentage of carbon dioxide which is coming out after the complete combustion process or even if you consider the example based on the 50% excess air also still you can calculate this particular percentage of carbon dioxide in the flue gas. So, here the example is, ethane is combusted with 50% excess air. So, in this example, the 50% excess air is used for the combustion process and which enters a combustion chamber at 25 degree C.

So, the inlet temperature is given as 25 degrees C here. Assuming the complete combustion in this process, determine the air to fuel ratio and the percentage of carbon dioxide by volume in the product. So, there are 2 things again we need to calculate here the air to fuel ratio and the percentage of carbon dioxide in the product gas. So, air to fuel ratio for the 50% excess air we already discussed in the previous example.

So, I am just continuing the same example so, that you can understand like how to calculate the theoretical air which is required for the combustion process and if it is given that 50% excess air is required for the combustion process. So, based on that also can calculate the theoretical as well as the 50% excess air to fuel ratio which is required for the combustion process. And again the same problem we are continuing to just calculate the percentage of carbon dioxide in the flue gas.

So, this is what is the attempt here to make you understand that with the given example, which is the same example, how we are extending the calculation. So, now, in this case if you see here as we already calculated the stoichiometri equation which is required for the 50% excess air when it is supplied for the combustion process. So, it is coming in the form of this. So, this equation you can even take from the previous example, but not necessarily that every time the C 2 H 6 as a hydrocarbon is given for the combustion process.

It can be a CH 4. It can be a C 3 H 8 right. So, accordingly you have to balance the equation and find out the exact number of moles of air which is required for the combustion process. So, here it is a C 2 H 6 again which is a ethane which is used for the combustion process. And once you complete this calculation, the final equation is coming in the form of, so, this is the final equation now. So, based on this we can calculate the air to fuel ratio which is required for the combustion process when 50% excess air is supplied.

So, in that case again the same value will come here that is 24.15 again. So, this indicates the air to fuel ratio which is required when the fuel is supplied with 50% excess air. Now, from this given amount, now, we have to calculate the percentage of carbon dioxide in the flue gas.

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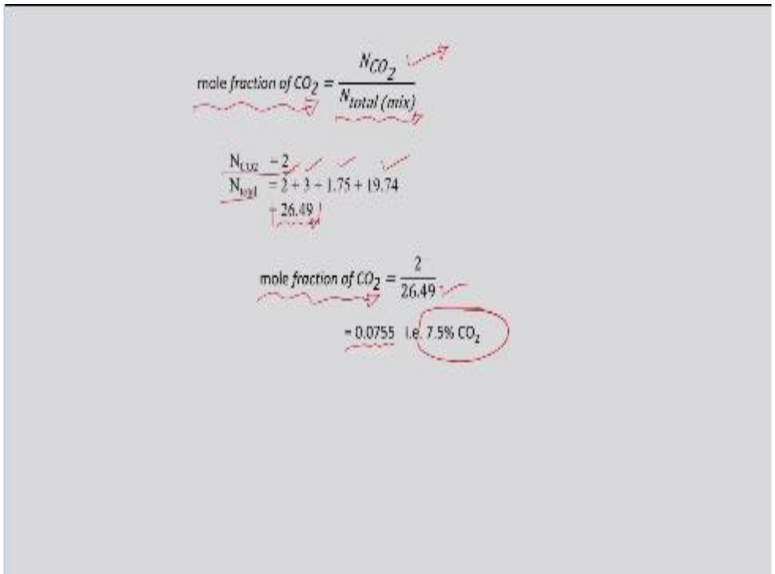

So, again here the concept is same because we know the mole fraction of CO 2 is equal to the number of moles of CO 2 in the product gas divided by the total mixture of the product gas that is n total or n mix. So, in this case, there are 2 moles of CO 2 in the product gas and the total mixture of the product gas. If you just try to make the summation of this number of moles, so, we will get the total number of moles in the product gas.

Or you can say the mixture of product gas that is around 26.49 that is 2 moles of CO 2, 3 moles of H 2 O, 1.75 moles of oxygen and this many moles of nitrogen are there in the product gas mixture. So, this indicates the total n and this indicates the number of moles of carbon dioxide in the product gas. So, from this, we can calculate the mole fraction of CO 2 that is 2 by 26.49 equal to 0.0755 that is 7.5% of moles of CO 2 are there in the product gas.

So, it gives the 7.5 mole percent of CO 2 in the product gas. So, this is how we can also calculate the moles of specific substance in the product gas. It may be in the form of O 2; it may be H 2 O; it may be even nitrogen. So, we can solve such examples considering the different fuels as I mentioned. So, with this, we end our module here that is module 8. This is also the last lecture of this course.

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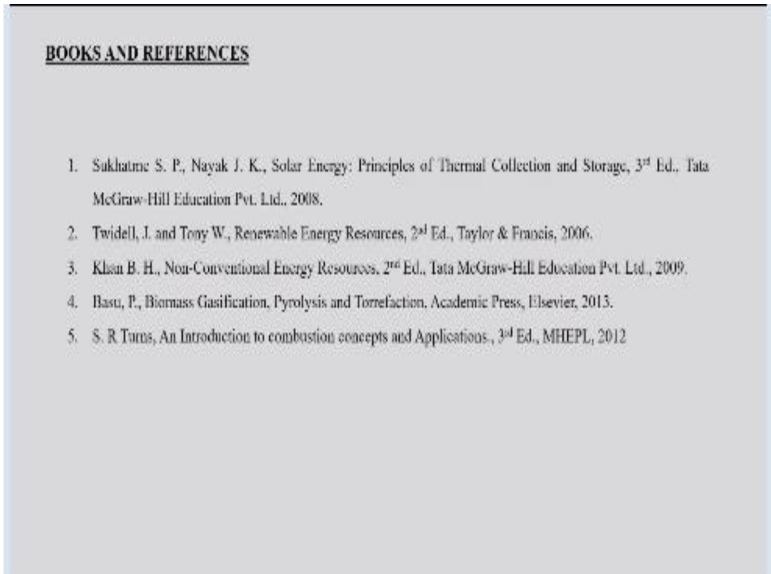

So, for the reference purpose, I suggest you to refer the books which are displayed on the screen and if you have any doubt regarding this lecture, you feel free to contact me at vvgoud@idg.ac.in. Regarding this course as well as the content of course, if you have any doubt, feel free to contact us at we will vvgoud@idg.ac.in or you can also contact to the anandalakshmi@iitg.ac.in. Thank you.