Waste to energy conversion
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Lecture - 16
Tutorial on Gasification

Hi friends, now we will discuss on the module tutorial on gasification. In this module we will solve some numerical problems on gasification.

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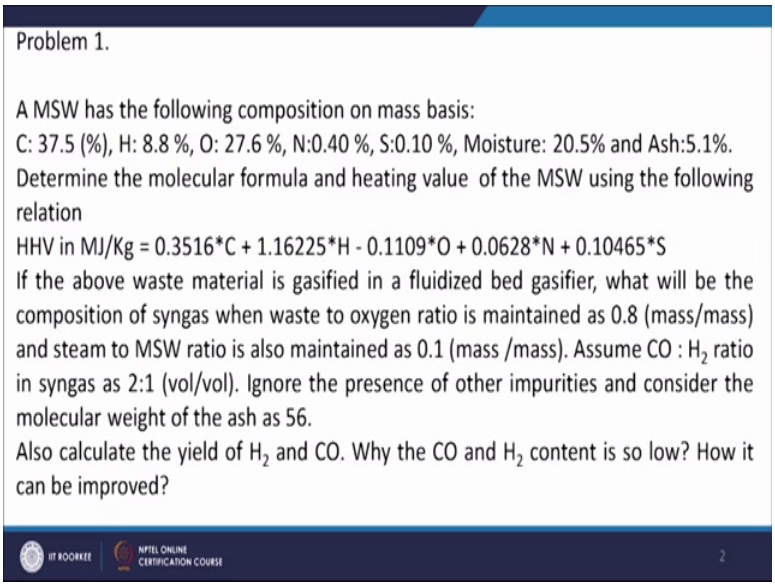

The statement of the first problem is a MSW has the powering composition on mass basis C 37.5 percent, H 8.8 percent, O 27.6 percent, N 0.40 percent, S 0.10 percent, moisture, 20.5 percent and ash 5.1 percent. Determine the molecular formula and heating value of the MSW using the following relation that HHV in m j per kg that is equal to 0.3516 into C plus 1.16225 into H minus 0.1109 into O plus 0.0628 into N plus 0.10465 into S if the above waste material is gasified in a fluidized bed gasifier what will be the composition of syngas when waste to oxygen ratio is maintained as 0.8 mass by mass and steam to MSW is ratio is also maintained as 0.1 mass by mass. Assume CO is to H 2 ratio in syngas as 2 is to one volume by volume, ignore the presence of other impurities and consider the molecular weight of the ash as 56.

Also calculate the yield of hydrogen and CO why the CO and H 2 content is. So, low how it can be improved. So, on the basis of these statements we have to determine 6

things. So, the first is we have to get the molecular formula of the MSW, then we have to find out the heating value then we have to calculate the composition of the syngas, 4th we have to calculate the yield of hydrogen and CO, and fifth we have see what is the CO and H 2 content and why it is so low and how it can be improved to solve this problem we have to take some basis.

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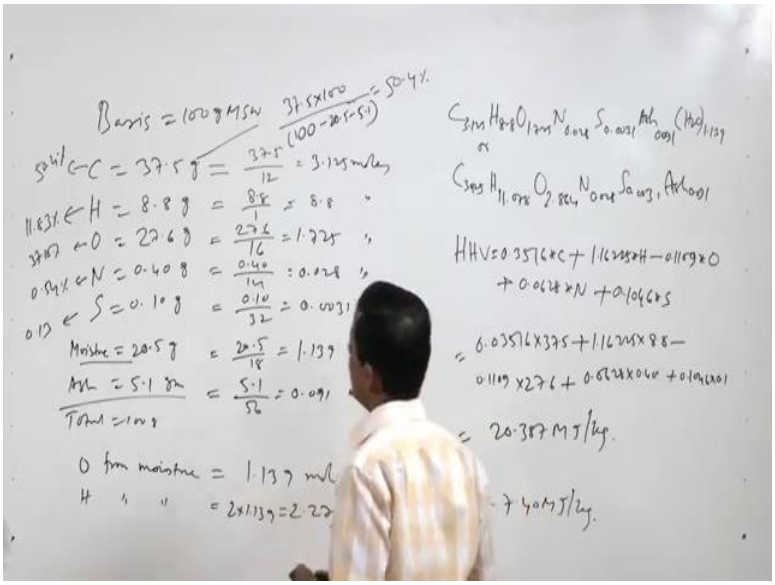

So, our basis is equal to say 100 grams of MSW. So, carbon present in this that is equal to 37.5 gram as 37.5 percent is carbon. So, hydrogen present in is equal to 8.8 gram. And then oxygen present in it is equal to 27.6 gram and N is equal to 0.40 gram, S is equal to 0.10 gram. And moisture is equal to 20.5 gram and S is equal to 5.1 gram. So, total we are getting 100 grams.

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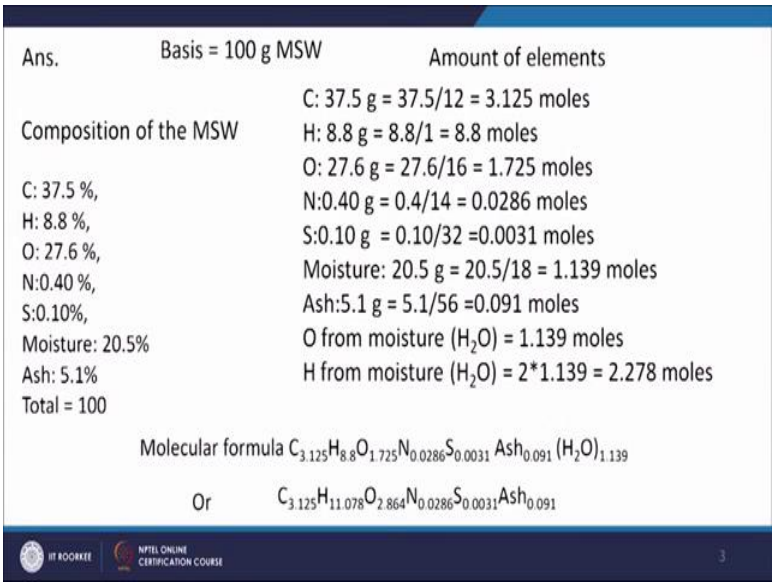

Now, this 37.5 gram we can convert it into molecules moles. So, that will be 3, 37.5 divided by 12. That is equal to we are getting 3.125 moles. And hydrogen will be 8.8 divided by 1 - 8.8 moles and then oxygen 27.6 divided by 32. So, it will give us sorry it is will be 16 not 32 this will be 16. So, it is giving 1.725 moles. Then nitrogen will be 0.40 divided by 14. So, that is equal to 0.028 and for sulfur this is equal to 0.10 divided by 32. So, that is equal to 0.0031 and for moisture 20.5 divided by 18. So, that is equal to 1.139 moles and for S 5.1 divided by 56. So, that is equal to it is coming 0.091 moles. So, these are the moles present in the MSW.

Now, another thing that the moisture which is present here this H 2 is composed of oxygen and hydrogen. So, we can calculate the oxygen from moisture is equal to one mole of H 2 is having 1 O. So, we are having 1.139 moles and hydrogen from moisture is equal to we are having 1.139 into 2. So, that is equal to 2.2 into 1.139. So, that is equal to 2.278 moles. So, if we want to the represent the molecular formula of this material we are getting that C that is equal to 3.125, H 8.8, O 1.725, N 0.028, S 0.0031 and ash we are getting 0.091 and H 2 O that is equal to 1.139 or we can write C 3.125, H 8.8 plus this 2.278. So, that is equal to coming 11.078 11.078 oxygen similarly 1.725 plus 1.139. So, it is coming 2.86 4. So, 2.864 N is 0.028 S 0.0031 ash 0.9 10.091. So, this is equal to. So, this is the molecular formula of the waste.

So, first part is complete the second part we have to determine the heating value. So, heating value HHV is equal to given HHV is equal to given that is equal to 0.3516 into C that is C is a percentage of carbon, then 1.16225 1.16225 into H minus 0.1109 0.1109 into O plus 0.0628 into N plus 0.1046 into S. So, this is the formula which is given. Here we can calculate the heating value considering the basis or wet basis or dry basis or dry and aspiri basis any basis we can calculate. So, if we want to on wet basis we will put the value 0.03516 into C. So, that in that case 37.5 plus 1.16225 into 8.8 minus 0.1109 into 27.6 plus 0.0628 into 0.4 plus 0.1046 into 0.1. So, that is equal to around say 20.387. So, 20.387 mega joule per kg this is on wet basis. Now we can convert it into dry basis or dry and aspiri basis anyone as you wish.

So, dry basis if began to do in that case C will be this will be 37.5 37.5 into 100 divided by 100 minus 20.5 minus 5.1. So, this will be on dry and aspiri basis. So, it coming 50.4 percent. So, 50.4 percent dry and aspiri basis it is coming 50.4 percent similarly the same formula will be used 8.8 into 100 divided by 100 minus 20.5 minus 5.1. So, it will give us the hydrogen is equal to 11.83 percent, oxygen will give us 37.10 percent and hydrogen will be 0.54 percent and sulfur will be 0.13 percent. So, if we put this value here in this formula then we will get the HHV on dry and aspiri basis. And that is equal to 27.40 mega joule per kg. Similarly, we can calculate on dry basis in that case we will remove the 0.51from here. So, that will give this only dry basis not dry and aspiri basis. So, any question comes either the HHV may be ask to determine on dry basis on wet basis on dry and aspiri basis. So, this way it can be solved. The next part of the problem is that we have to find out the composition of the syngas.

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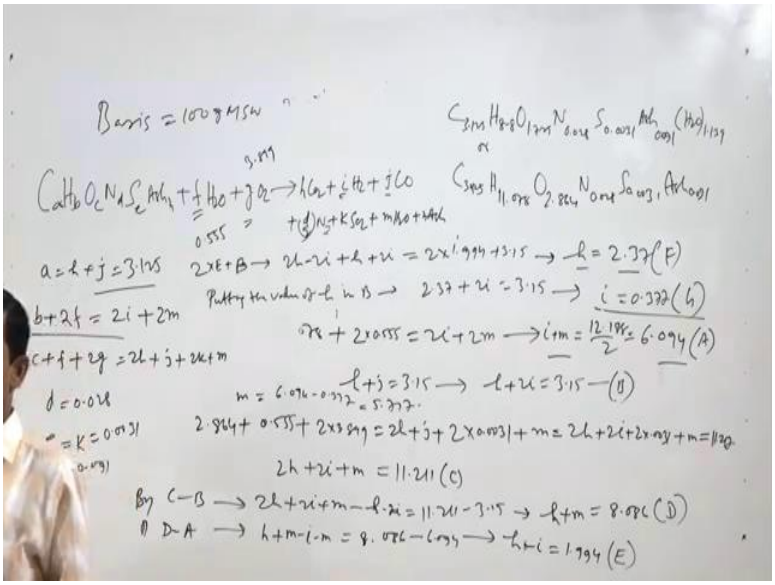

So, for the to finding out the composition of the syngas; obviously, we need to get some mathy mythical representation of the reactions. So, the mathematical representation of the reaction is declared. So, that is here assumed that C a H b C a H b O C N d S e ash N plus f H 2 O plus g O 2 that is giving us H CO 2 plus i H 2 plus j CO plus d by 2 N k S O 2 plus m H 2 O plus m ash. So, this is a reaction we are assuming. Now we have to find that the value of a b c d e n f g h i j k m and n. Then we can get the how much see if you get the value of H from this much of amount of material, how much you to will be produced to you can calculate if you get the value of i, how much hydrogen is produced you can calculate if you get the j we can get the moles of CO produced if you get the k and name value correspondingly S O 2 and S 2 produced we can calculate. So, that will be our job now. So, if we do the elemental mass balance. So, for carbon balance we can write a is equal to 2 H a is equal to, a is equal to h plus not 2 h, h plus this h plus j. So, this plus j and a is equal to how much we have got a is equal to 3.125 3.125 we are getting here.

Next is we will do hydrogen balance. So, left side left hand side is b plus 2 f right hand side is equal to 2 i, 2 i, plus 2 m. So, this is for hydrogen balance if we go for oxygen balance then we will get C plus f plus 2 g C plus f plus 2 g is equal to 2 h plus j plus 2 k plus m. Now d is equal to nitrogen balance. So, d is equal to how much d is equal to 0.028 0.028 and then e by sulfur balance e is equal to k and e is what that is equal to 0.0031 that is 0.0031.

Now, N is equal to 0.091 now we have got these values and some relationship. Another condition is given what is that CO and H 2 ratio in the syngas CO and H 2 ratio in the syngas is given that ratio is CO is to S equal to 2 is to 1. So, CO is to S 2 is equal to 2 into 1. So, 1 is CO is to S 2 is equal to 2 is to 1 in syngas. So, that is giving us that this i and j this relationship. So, j is equal to 2 i and another is also given mass of MSW by mass of oxygen is 0.8. So, mass of MSW by mass of oxygen is equal to 0.8, it is given in the statement. So, our molecular rate of the MSW molecular rate are of the MSW will; obviously, be around 180 gram as you have taken it. So, it coming 99.8156 gram therefore, mass of O 2 used for mole of MSW. So, mass of oxygen used per mole of MSW will be mass of O 2 used per mole of MSW is equal to 99.856 divided by 0.8 that is equal to one 24.77 gram that is equal to this 124.77 divided by 32. So, that is we will that is equal to 3.899 moles of oxygen. So, oxygen we can use for this MSW that is equal to 3.899 moles. So, now, we have got the value of g. So, we have got the value of g that is equal to 3.899 moles. And we have got some mathematical expression also.

Now, another information is given that is the steam and MSW ratio. So, mass of steam by mass of MSW is equal to 0.1 mass of steam by mass of MSW is equal to 0.1. So, H 2 O or steam used H 2 used during gasification is equal to how much used is equal to 0.1 into the 99.856 gram that is equal to 9.98156 gram. So, if we convert this in gram into moles. So, that will be divided by 18. So, 0.555 moles 0.555 moles. So, these moles of steam is used. So, now, we have got the value of f. So, that is equal to 0.555 moles we have also got some expression. Now from these expressions we have to get value of i, we have to get the h and n. So, we have 3 expressions 1 2 3 and we will get 3 variables. So, we can solve it. So, here we see 1 plus j is equal to 3.125 and we have got b plus 2 f equal to this. So, b is equal to what b is equal to 11.078. So, b plus 2 into f f equal to what 0.55 these 2 we are getting. So, that is equal to 2 i plus 2 m. So, this gives us i plus m is equal to this plus this divided by 2. So that is coming 12.188 divided by 2 that is equal to 6.094 say we are putting this equal to a equation a.

Another expression we are having C plus a plus 2 g. So, what is our C? C is equal to here 2.2. That is oxygen content that is equal to 2.8642.864 plus f f is equal to 0.55 and 2 g. So, 2 into 3.899. So, this is the left hand side and the right hand is equal to 2 h plus j plus 2 k plus m. So, 2 k 2 into 0.0031 plus m. And another expression we have here that is CO by H 2 equal to 2 or j equal to 2 I. So, j equal to 2 i 2 I. So, if we put this j equal to 2

i here. So, this will be equal to 2 h plus 2 i plus 2 into 0.0031 plus m that is equal to we are getting this part is coming equal to 11.21 711.21 7 that part is coming is equal to 11.217 or we are getting 2 h plus 2 i plus m that is equal to 11.27 minus this 2 in 20.0031. So, that is equal to 11.211. So, we are putting into equal to C and we have h is equal to h plus j is equal to 3.15. So, h plus j is equal 3.15 if we put the j equal to 2 I. So, we can write h plus 2 i is equal to 3.15. So, we are putting into equal to b.

Now, by using this a b C we can calculate the value of H I N m. So, minus C by C minus me b. So, this minus this if we make C minus b. So, 2 i 2 i will cancel. So, by C minus b we are getting 2 h plus 2 i plus m minus h minus 2 i that is equal to 11.211 minus 3.15 their h plus m is equal to this is giving us h plus m is equal to 8.0868.086 now we have giving it that equation d again by d minus a by d minus a by d minus a we are getting h plus m minus i minus m. So, what is d h plus m what is a i plus m. So, minus i minus m. So, we getting here this equal to 8.086 minus 6.094 that is equal to H minus i that were that is giving us H minus i that is equal to 1.994 we are giving an equation e.

Now, by 2 into e plus b if we multiply 2 into b plus e 2 into e plus b by 2 into e plus b it will give us 2 h minus 2 i and b plus h plus 2 i that is equal to 2 into 1.994 plus 3.15. Or h equal to h equal to we are getting 2.37. Now we are putting it as f now we are having e. Now we have got f then what we will do putting the value of h in b which value we are getting here the value of h which are getting here if we put the value of h in b then you will get the value of i. So, 2 i putting the value of putting the value of h in b we get 2.37 plus 2 i is equal to 3.15 or it is giving i is equal to 0. 377. So, that is equal to say g that is equal to g. Now we have got the value of i we have got the value of h. Now we need to get the value of m. So, from g and a from expression g and from expression a we will put the value of i here and will get the value of m. So, m is equal to. So, m is equal to that is equal to 6.094 minus 0.337 it is coming 5.717.

So, now we have got all the value of i j h m etcetera. So, one the basis of this value now we can see the composition of the syngas. So, on the basis of this we get the value of syngas composition also.

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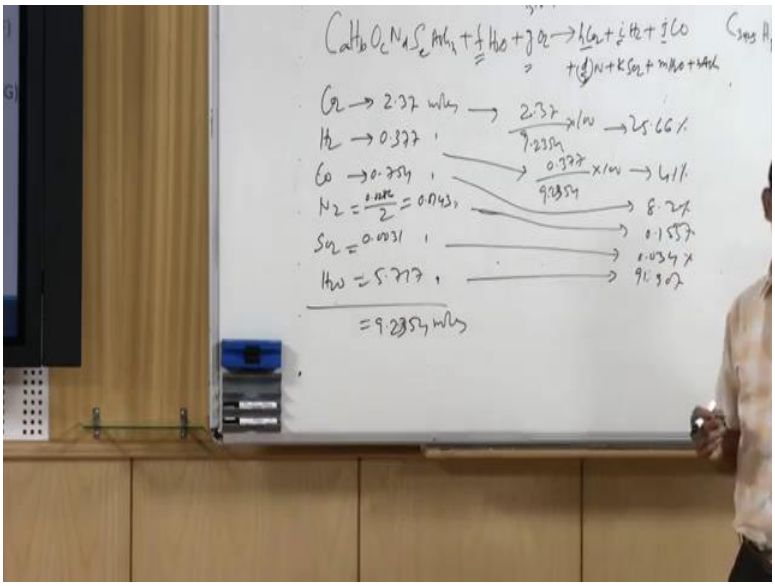

What would be the CO 2? CO 2 is equal to how much h. So, h value is equal to 2.37. So, 2.37 and then will get H 2, H 2 is equal to 0.377 and then we will get CO C O is equal to 0.754 and then we will get N 2 that is equal to N 2 is equal d by 2. So, d is equal to here we have got 0.0286. So, that divided by 2. So, 0.0143 and now we are getting S O 2 S O 2 is equal to 0.0031 moles and now we are getting H 2 O is equal to 5.717. So, these are the moles which are present in this.

So, if we get the total moles. So, total moles is coming 9.9.2354 moles. These are the moles then we can get the percentage. So, we can get the percentage, if we get the percentage of CO 2 that is 2.37 divided by 9.2354 into 100 which is giving us 25.66 percent similarly for hydrogen it is coming 0.377 divided by 9.2354 into 100. So, it is giving us 4.1 percent. So, 4.1 percent similarly for CO, it is for CO it is coming 8.2 percent for nitrogen it is coming 0.15 percent and for S O 2 it is coming 0.03 percent and for H 2 O it is coming 61.90 percent. In the next part of the problem we have to explain why this CO and H 2 is less here maximum O, H 2 O, and CO 2 is produced; that means, oxidation has taken place and this is because of the higher oxygen to MSW ratio and also using more steam.

So, this is the reason for which we have got less CO and less H 2. So, this concentration can be improved by using less H 2 O and less O 2 and the last part we have to determine the yield of hydrogen and CO.

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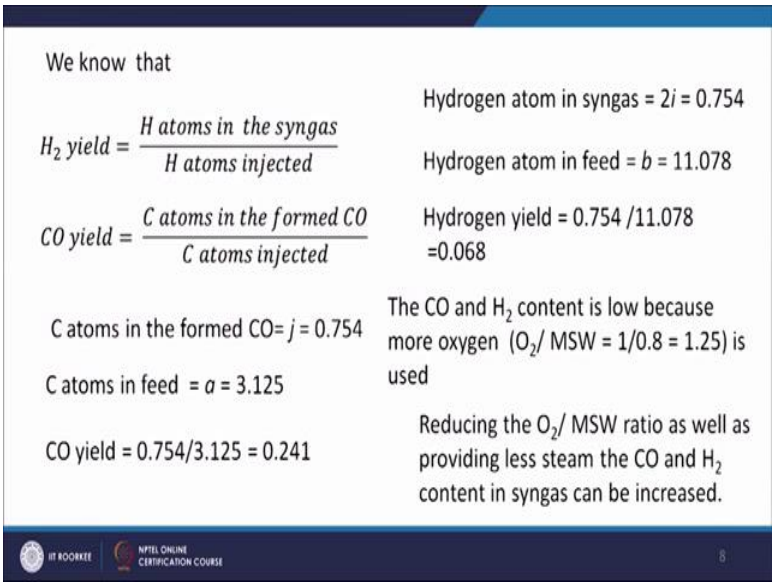

So, yield of hydrogen is hydrogen atom in the syngas by hydrogen atom in the injected if it is being injected. So, the hydrogen atom in the syngas is 2 i that is equal to so, hydrogen atom in the syngas is equal to 2 into i and hydrogen atom in the feed is equal to this b. So, the yield of hydrogen is equal to the 0.754 divided by 11.078. So, that is equal to it is coming 0.068 similarly for CO the yield is equal to carbon atoms in is found in CO divided by carbon atoms injected.

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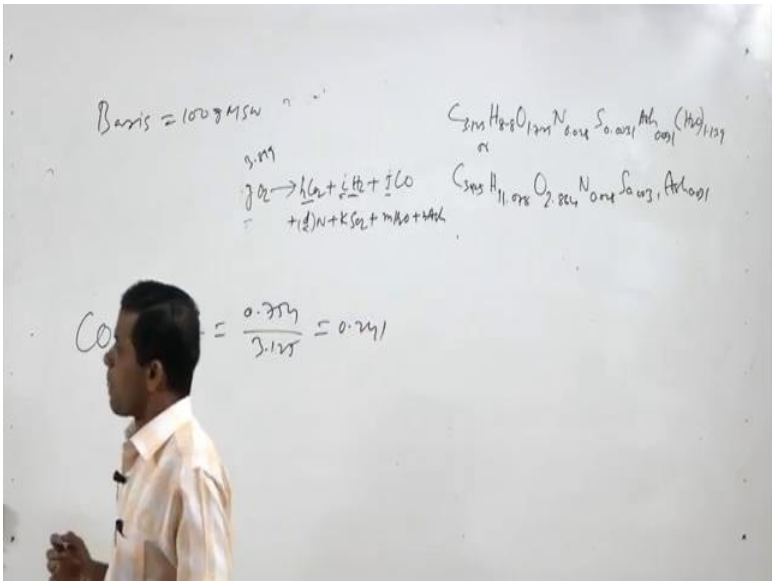

So, in this case the yield of CO is equal to j divided by a and j is equal to 0.754 and a is equal to 3.125. So, it is giving us is equal to 0.241. So, now, we have completed all the parts of this problem.

Thank you very much for your patience.