Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems
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Lecture - 30
Practice Problem

Hello everyone, welcome to part 1 of lecture 3 under model 8. In this lecture, we will practice few examples on the theory covered in the gasifier. So, gasification of the biomass in the gasifier, it mainly produces the producer gas and the gas produced from the gasifier after cleaning by removing some unwanted gases as well as some particulate matter, then it can be utilized for the power generation.

Apart from that, it can also be used as a heat source, but here in this particular examples will be mostly focused on the utilization of this particular produce gas from the gasifier to produce the power. So, let us discuss the examples in the similar line.

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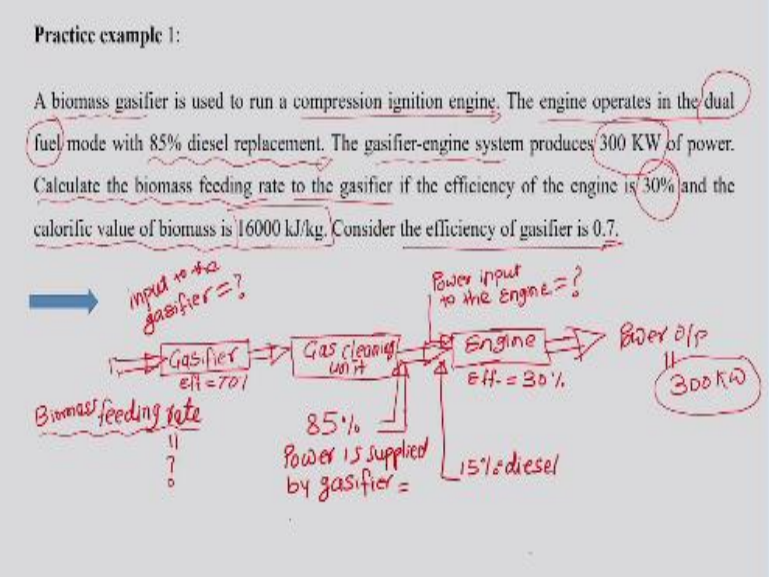

So, the first example which is displayed here, a biomass gasifier, it is used to run a compression ignition engine. So, the purpose of this particular gasifier is now, the produce gas from the gasifier, it is used to run the compression ignition engine and the engine operates in the dual fuel mode that means, it is operating using a 2 fields. One is diesel and the part of the operation is being carried out using the gas produced from the gasifier. So, that is why it is called as a dual fuel mode engine.

And in this 85% of the diesel replacement is done by the producer gas produced from the gasifier. Remaining 15% of the power is produced by the diesel and 85% of the power is produced by the producer gas supplied from the gasifier to the engine to produce the output power and the gasifier engine system, it produces around 300 kilowatt amount of power, it indicates that how to calculate the biomass feed rate to the gasifier.

If the engine efficiency here it is mentioned as 30% and the calorific value of the biomass which is used in this example is 16,000 kilojoules per kg whereas, the efficiency of the gasifier is 0.7. So, now, based on this given data, let us draw a small schematic first just to understand how this gasifier is used to run the engine and produce the power and then based on that particular schematic, we can easily find out what is the given data and from that given data, how to calculate the biomass feeding rate.

So, now, let us draw one small schematic first. So, here if you see, this is a suppose, gasifier just for the representation purpose, consider this as a gasifier and this particular gasifier after producing the gas, the gas is passed through suppose gas cleaning unit. So, in this particular operation, mainly the particulate matter and the unwanted gases have been removed from the particular gas produced from the gasifier.

So, here there is no reaction happening in this particular step, only it is a physical method, just to remove the unwanted particles which are present in the producer gas as well as to remove the unwanted gases which are present in the producer gas, so, that accordingly we can increase the calorific value also of the particular gas. After this gas cleaning unit, it is fed to the engine for the generation of power.

And in this case, the power output is equal to around 300 kilowatt. So, now, based on this 300 kilowatt amount of power, we have to find out here the feeding rate that is a biomass feeding rate. Biomass feeding rate to the gasifier that need to be calculated in this particular stage. Accordingly, if you see in this case, as it is mentioned 85% of the power is supplied by this, particular power is supplied by gasifier and remaining 15% is coming from the diesel.

So, this is how the distribution of the field we can see here the 85% of the field is coming from the gasifier and the remaining 15% is coming from the diesel. So, how to get there is nothing but we have to calculate here the total power or you can say the power input to the

gasifier. So, this particular quantity also we need to estimate here that is how much is the total power which is input to the engine.

And then based on that particular power as the efficiency of the engine is given as 30%. So, engine is operating at 30% efficiency. So, accordingly by conversion of this particular input power with 30% efficiency, we can get the total amount of power which is produced by the engine. So, first we need to calculate the power input to the, it is not a gasifier here, power input to the engine. So, this is a power input to the engine.

So, once we know the total amount of power which is fed into the engine to produce 300 kilowatt amount of power accordingly, we can calculate the power which is supplied by gasifier to the engine to produce 300 kilowatt amount of power and also based on that here we can calculate the input to the gasifier. Because, a gasifier is also fed with biomass with certain feeding rate just to produce the same amount of the power.

The gas produced from the gasifier is getting clean in the gas cleaning unit and then it is passed to the engine for the power generation purpose. So, the input to the gasifier, if you see here, it can be also calculated using the, once we come to know the power which is supplied by the gasifier, accordingly, we can calculate the input to the gasifier, because here the gasifier efficiency is given as 70%.

So, now, this is all is the given data. Based on this given data, now, we can simply calculate the power which is supplied by the gasifier as well as based on that you can calculate the biomass feeding rate also. So, now, let us see the calculation step by step.

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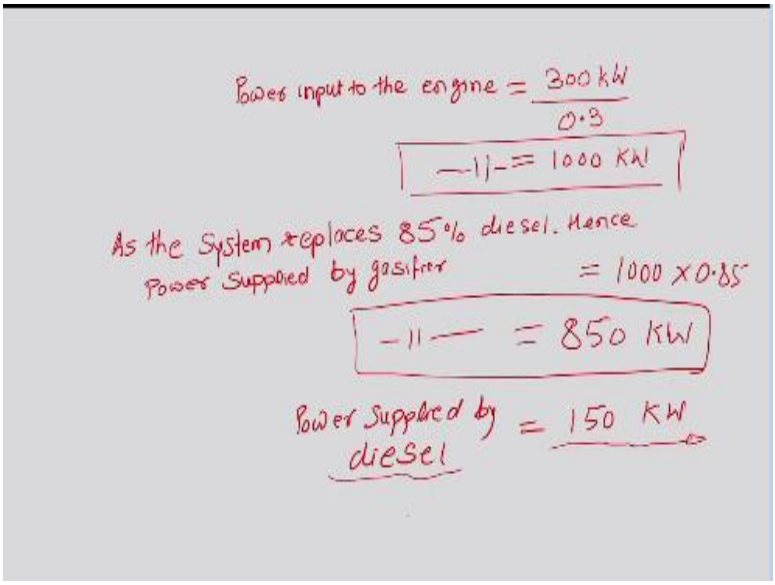

So, first we can calculate the power input to the engine. So, how to calculate this because as we know the total power which is produced by the engine is 300 kilowatts and engine efficiency is only 30%. So, if you just divide it by the engine efficiency, we can automatically get the power which is input to the engine and it will be around like 1000 kilowatt. So, this is the amount of power which is input to the engine.

So, now, once you know the total amount of power which is input to the engine, So, based on that because, it is already mentioned there as the system replaces 85% diesel with a producer gas. Hence, power supplied by gasifier is equal to how much so, because we know that 85% of the power is coming from the gasifier. Total power is 1000 kilowatt which is input to the engine.

So, accordingly we just simply multiply this 1000 into 0.85 that is 85% that is equivalent to 850 kilowatts. So, this is the power which is supplied by gasifier to the engine which is around 850 kilowatt. So, the remaining fraction is nothing but the power supplied by diesel and it is 150. You can simply just subtract 850 from the 1000. So, it gives the power which is supplied by a diesel to the engine. So, totalities coming around like 1000.

So, one point we got in this example now that the total input to the engine is 1000 kilowatt. So, now based on this power which is supplied by gasifier, we can further calculate the input to the gasifier and then based on that, we can calculate the feeding rate to the gasifier. So, we can just try to calculate these values one by one.

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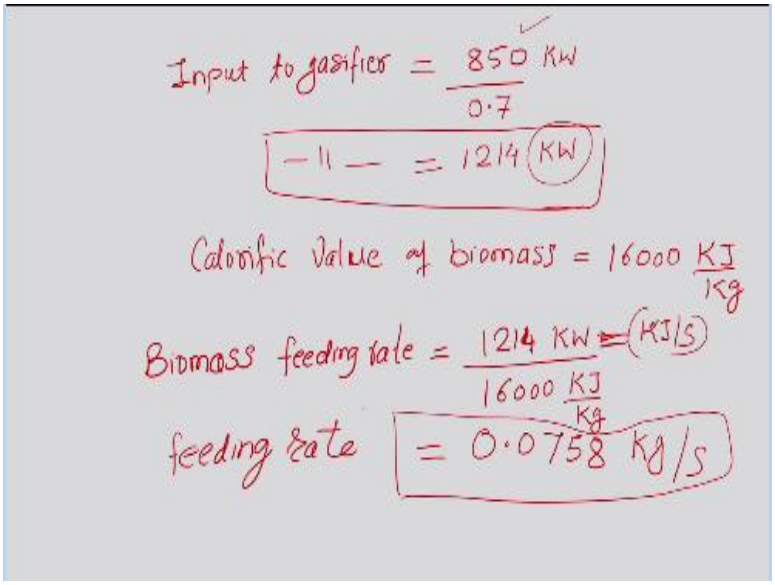

So, now, once we know that the power supplied by gasifier is 850 kilowatt. So, now the input to gasifier can be calculated very easily from this particular given value of 850 kilowatt, which you have obtained in the example just right now. So, input to the gasifier is simply 850. So, this particular value is considered as a output from the gasifier and we know the efficiency of the gasifier is given as 70%.

So, simply if you divide this value by efficiency of the gasifier. So, you can calculate the power input to the gasifier and it is coming as roughly around 1214. So, this is the amount of power input to the gasifier. And then based on this input to the gasifier, because of the 70% efficiency of the gasifier, it is producing around 850 kilowatt amount of the power and this particular power is again supplied to the engine power. The power output that is in terms of the usable power.

So, now, once we know these particular power, which is input to the gasifier and it is in the kilo watt, we also know the calorific value, calorific value of biomass. So, the calorific value of biomass given in this example is 16,000 kilojoules per kilogram. Now, once we know this calorific value of the biomass and we also know the input to the gasifier. So, using these 2 quantities, you can easily calculate the biomass feeding rate to the gasifier.

So, the biomass feeding rate is equal to because we know 1214 this is in the kilowatt, this is a 1214. So, 1214 is the input to gasifier. And then the calorific value is given here is 16,000, which is again in kilojoules per kg. So, what we will do here in this case is now? As we know, this is a power in kilowatt. So, simply we can convert this value in kilojoules per

because this is kilowatt, so kilojoules per second is a kilowatt, it is equal to kilojoules per second.

So, once you divide this term here, what happens is like, you get the value in the form of 0.0758, so, the kilogram and this as kilogram per second. So, this is the value that is a feeding rate to the gasifier. So, with this feeding rate of biomass, the output which is coming out from the gasifier is 850 kilowatt amount of the power which is coming out, so, that is equivalent to the producer gas which is coming out from the gasifier.

And the produce gas from the gasifier after cleaning it, it is fed into the engine for the power generation purpose and based on that conversion efficiency of the engine; it is converted into a 300 kilowatt amount of the power. So, now, this value which is given here, it is the kilogram per second.

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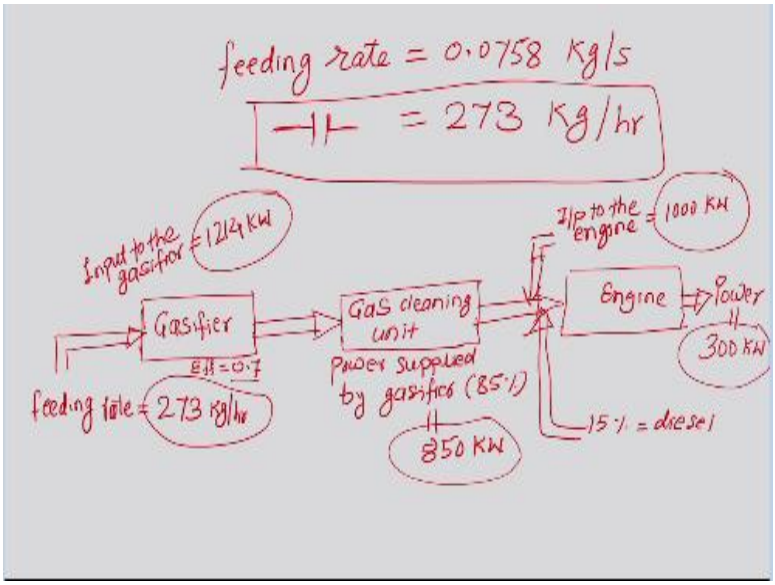

So, now once we know the kilogram per second value, we can convert this value in the, so, the feeding rate here is 0.0758 kilogram per second. Now, just convert this second into an hour, so, simply we have to just multiplied here by 3600 that is second and then into the minute conversion, so, we will get the value in the form of 273 kilogram per hour. So, this is the biomass feeding rate to the gasifier.

So, now, once you understand all these values, how we have calculated value, let us redraw the schematic which are drawn at the beginning of the example, which will give us the clear idea that what is the amount of input is required to the gasifier to produce significant amount

of the quantity of the producer gas and based on the gas which is produced in the gasifier, after cleaning it, if you fed into the engine for the power generation purpose, it can produce significant amount of the power as well.

So, now, let us redraw the schematic and then try to see like the unknown quantity and how we have calculated that quantity you already know. Just with the unknown and known quantities, we just have to complete the schematic which you have done at the beginning of the example. So, this is again is a gasifier. This is a gas cleaning unit and after cleaning the gas, it is fed into the engine for power generation.

So, it is giving power which is equivalent to 300 kilowatt. So, at the beginning in the example, it was asked to calculate the feeding rate to the gasifier and then we calculated the feeding rate to the gasifier also. So, that feeding rate is around 273 kilogram per hour. Here, the efficiency of the engine 0.7 and then based on that we calculated the input power input to the gasifier. So, input to the gasifier is coming around 214 and it is in the kilowatt.

So, based on this input to the gasifier 70% efficiency, the power supplied based on that the power supplied by gasifier is calculated because it is 85% of the total power which is supplied to the engine. So, based on when you are calculate, it is coming around 850 kilowatt amount of the power and then the input to the engine is 1000 kilowatt out of that 85% of the power is supplied by the gasifier or we can say that 85% of the energy is supplied by the gasifier here remaining 15% is by diesel.

So, now, once we see this entire schematic, so, here, we have calculated this value 1214. We also calculate this value here and then based on this, this is also the calculated value from the given data. So, these 3 value we have calculated and apart from that, this is the total power which is input to the engine, the value also we have calculated here. So, based on these values, this is the amount of the power produced by the engine.

So, this all discuss about the gasifier and the producer gas from the gasifier, how it can be utilized to produce the power using the engine. So, with this example, we can understood like how to calculate the feeding rate to the gasifier if the power output from the engine is given. In the other way, you can also calculate the power output from the engine if the feeding rate is given.

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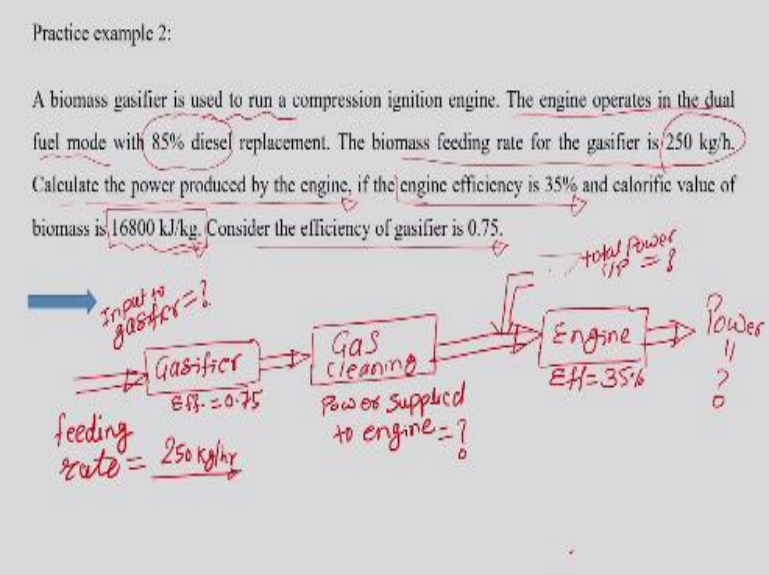

So, let us see another example, a biomass gasifier is used to run a compression ignition engine again, as mentioned here is also running on the dual fuel mode. Again the replacement is 85% of the diesel replacement is happening in this case also and biomass feeding rate to the gasifier, it is given as 250 kilogram per hour. So, now, in the previous example, in this case, the engine output power was given that is 300 kilowatt.

Now, here it is a biomass feeding rate it is given and now, we have been asked to calculate the power produced by the engine. So, just it is the other way example now and engine efficiency, it is slightly changed in this case, the calorific value, it is also slightly different and the previous value and efficiency of the gasifier is also slightly different. So, now, based on this given data, let us try to calculate the power output from the engine.

So, again just redraw the schematic which we have drawn in the earlier example as well, here again it is a gasifier and then there is a cleaning unit that is a gas cleaning unit again or a gas option after the cleaning is supplied to the engine for the power generation purpose. But in this case, now, the power output value need to be calculated whereas, the feeding rate to the gasifier is given.

So, here the feeding rate is given as 250 kilogram per hour and gasifier efficiency which is mentioned here is 0.75 and the power supplied power supplied to engine can also be calculated here, because based on that only we can calculate the total power which is output

from the engine and then accordingly also if you see here, we can also calculate the total power input to the engine.

So, with this given data, apart from that the engine efficiency is given as 35. Now, based on this, we need to calculate the power output from this specific gasifier. So, now, if you see here in this case, the feeding rate is given as 250 kilogram per hour. So, accordingly we can calculate the input to gasifier. This also, we can calculate very easily because we know the calorific value of the biomass here.

And once we know the calorific value of the biomass, we can easily calculate the input to gasifier and this is the input to the gasifier value. So, now, this is the small schematic which we have drawn. So, based on the given data now, let us calculate the power output from the engine, because here the biomass feeding rate value is given.

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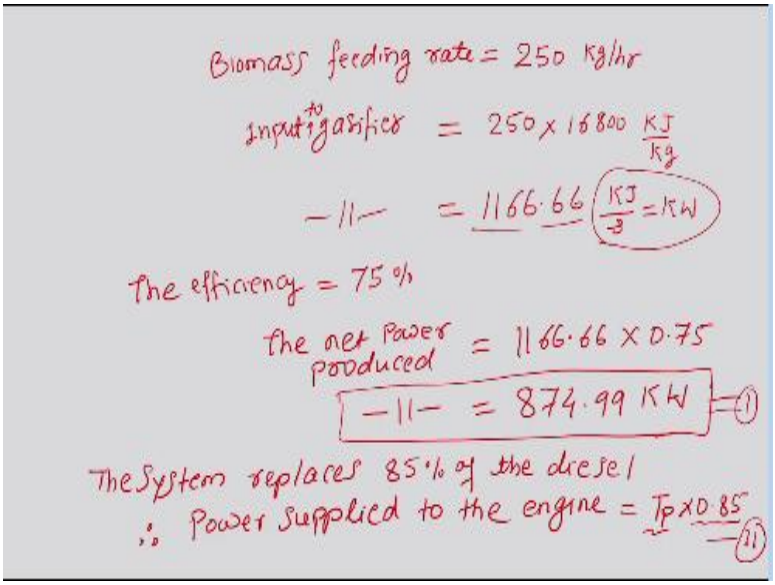

So, the biomass feeding rate is 250 kilogram per hour. So, **(( )) (23:31)** value, we can simply calculate the input to the gasifier because we know the calorific value of the biomass and the feeding rate is 250 kilogram per hour. So, the input to gasifier is simply 250 into, this is in kilojoules per kilogram, whereas, these values in the kilogram per hour, so, this kilogram will get cancelled and we will get the value in the form of suppose 1166.66.

We just convert this hour into second and then the value will be equal to 1166.66 kilojoules per second or we can also call it as in kilowatt. So, this is the power or we can say this is the net input to the gasifier. So, from this input value, we can simply calculate the output from

the gasifier as well, because we know the efficiency of the gasifier. So, the efficiency of the gasifier is given as 75%.

So, based on this efficiency of the gasifier, we can calculate the net power which is produced by a gasifier. So, what you have to do in this case is like 1166.66. So, this is the input to gasifier. So, simply multiply by the gasifier efficiency and it gives the value in the form of 874.99 kilowatt. So, this is the net power, which is produced by the gasifier by using efficiency of around 75%.

And this power produce is the power which is also fed into the engine because, this is also we are assuming here that whatever the power which is coming out from the gasifier, the same amount of the power is fed into the engine to get the output power. So, now, once we consider this is the net power which is produced by the gasifier, which is equivalent to the power fed into the engine.

So, based on that we can simply calculate because we know the system replaces around 85% of the diesel. Hence, based on this, the power supplied to the engine is equal to total power into 0.85. Why it is so? Because, out of the total power of the engine 85% contribution is from the producer gas produced by the gasifier and the remaining 15% is from the diesel. So, total power if you just multiplied by the 0.85, it gives you the contribution coming from the producer gas.

So, now, already we know the net power which is produced by the gasifier. So, once we create this suppose equation 1 here and this is equation 2.

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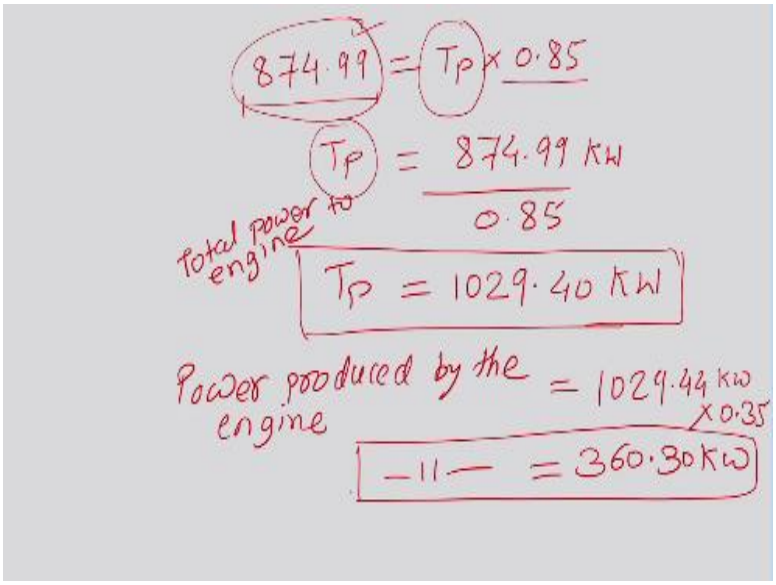

So, once we equate these 2 values, it is 874.99, which is equivalent to a total power into 0.85 because 85% of the contribution of the power is coming from the gasifier output and the gasifier output is this much. So, the total power will be simply divide the value by 0.85. So, this is in the kilowatt. So, total power produces 1029.40. So, out of this total power, this is the power supplied **(( )) (27:55)** gassifier output and the remaining power is supplied by the diesel.

As we know the power produced by the engine can be calculated very easily from here because this is the total power which is input to the engine. So, this is total power. So, once we know here because this is the output power from the gasifier and this is the total power which is input to the gasifier out of which 0.85 is the power coming from the gasifier output. So, once you just divide this value here, so, this is equivalent to a total power to engine. So, this is the total power which is fed into the engine to produce the output.

So, if this is the total power, so, from this total power as we know, because the engine is operating at a efficiency of 35%. So, the power produced by the engine is simply we can multiply this 1029.44 into 0.35, because this is in the kilowatt, so, we will get the equivalent value of 360.30 kilowatt. So, this is the power which is produced by the engine. So, now, based on the feeding rate, which is 250 kilogram per hour. So, the power produced by the engine is 360.30 kilowatt.

So, now, just by changing one of the parameters in the example, we can calculate either the power output from the engine or if the power output is given in the example, we can calculate

also the biomass feeding rate to the engine. So, I hope now it is clear from this example like how to calculate the power output or other you can calculate the feeding rate to the gasifier as well.

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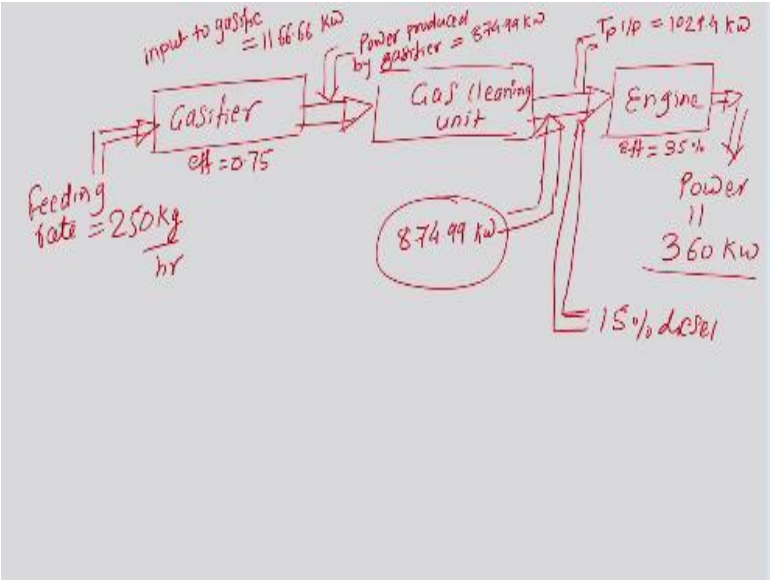

So, now, just let us try to complete this schematic which are drawn in the first slide of this example, here again it is a gasifier which is fed with the feeding rate of biomass is given which is 250 kilogram per hour. And accordingly the net input to gasifier also calculated as around 1166.66 kilowatt and then the produce gas is fed to the gas cleaning unit to clean the gas and remove the unwanted particle as well as the unwanted gases from the produce gas and then the clean gas is fed to the engine for the power output.

So, the value which we are calculated in this case is if you see here, so, this particular value is coming out around 360 kilowatt and accordingly if you see the 85% of the power contribution which is coming from the gasifier and this value is around 874.99 kilowatt and the remaining 15% is from diesel. So, now, once we know this value, so, the net or you can say the total input, total power which is input to the engine that we are calculated around 1029.4 kilowatt.

So, this is the value which is total input to the engine and as this engine has the efficiency of around 35%. So, based on that the output is coming at around 360 kilowatt and once we know this value here, the power which is produce, power produced by gas if it is close to 874.99 kilowatt and already we have mentioned here. So, this is the power which is produced by the gasifier and the efficiency of the gasifier was given as.

Now, with this we have completed the schematic now, we got all the values from the given data that we also got the power output from the engine based on that we also calculated the total power which is input to the engine. So, this is the total power which is coming from the diesel as well as from the gasifier. 85% of the contribution is from the gasifier; 15% is a diesel and that total power is 1029.4.

So, from the power produced by the gassifier could calculate the power output from the engine. So, with this I hope now, we could able to understand like how to calculate this power output value from the engine. If the biomass feeding rate values are given, we can also calculate the power output or another way, if the power output values are given, we can calculate the biomass feeding rate for the gasifier.

So, with this I guess you can solve some few more examples, if it is given in the assignment. If you have any doubt regarding this particular lecture, as well as regarding the content of this lecture, just feel free to contact me at vvgoud@idg.ac.in. So, in the next lecture, which is a again the part of the lecture only, we practice few more examples on the compression of the fuel. Thank you very much.

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