Clean Coal Technology

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Week-12

Lecture-57

Hi, I Professor Barun Kumar Nandi welcome you in NPTEL online certification course on clean coal technology. We are at module 12 discussing UCG, CBM, CMM and case studies. So, in the previous lecture, I have discussed underground coal gasification. In this lecture, I will be discussing coal bed methane, recovery of methane gas from coal bed. So, let us start lecture 2 on coal bed methane.

Coal bed methane or very well known as CBM, this is an unconventional source of natural gas which is now considered as an alternative source to meet our Indian energy demand. So, this term refers to the methane which is adsorbed in the solid matrix of coal and typically this gas is called as sweet gas because it is lack of H2S or hydrogen sulphide and the presence of this gas is well known for its occurrence in underground coal mining where it presents a serious safety risk. now if we see what is this actually this coal bed methane is that during the formation of coal or during the coalification process different types of biomass woody material and other they go for continuous degradation process and during this degradation process the hydrocarbons present in the feedstock or tree plants their residue they go for different type of continuous chemical reaction in the presence of heat pressure microbial activity etc. which happens as part of coalification. Now as part of this coalification by such process what happens?

The hydrogen rich material similarly and other lightweight gaseous materials, they come out from the coal structure. As a result inside the coal, carbon content increases and hydrogen and other material decreases. As carbon content in the coal increases, coal goes for the different type of upgradation. like from peat to lignite to bituminous to anthracite, etc. So, by such process, as the carbon content of the coal increases continuously, some of the hydrocarbon gases and other gaseous materials, they released from the hydrocarbon structure. So, these gaseous materials or these vapor materials Come out of the coal structure. Particularly, they are not part of coal hydrocarbon. They remain as individual gases. Like if I say this is the hydrocarbon source.

It goes for coalification. It makes some coal. And it makes some gases. Which are rich in different types of gases. Like methane, hydrogen, and others. It can also have ethane. And similar many gases are released as this biomass or woody material goes for continuous degradation. Coal rank increases, going from peat to lignite, and in this way, as a result, the carbon percentage in this coal increases and the hydrogen percentage in the coal decreases. So, during this process, all and similar types of gaseous materials are released. Now, this gaseous material If the soil characteristics or rock characteristics are highly porous, this gaseous material will come out of the coal layer or the coal seam. So, depending on the rock characteristics, soil characteristics, surface structure, porosity of the coal, and other materials, this gaseous material will They can come out if the inside pressure is significantly higher. These gases can come out, and if the rock or nearby soil characteristics are such that they allow these gases to escape, these gases continuously go out of the coal structure. So, these gases will come into the environment in a natural process at a very slow rate, as this coalification process takes a lot of time millions of years.

So, as in normal cases, this coal will not have these gases to a higher extent. That means these gases like methane, ethane, hydrogen, and other similar hydrocarbon-rich gases will be present in the coal structure, but not in a higher quantity if the soil or rock is porous in nature. But if the soil or rock is very much non-porous, they do not allow these gases to escape. So, all these gases will stay inside the coal seam. Whatever coal is there inside this coal seam, these gases will be present as individuals. So they will not be part of the coal; rather, they will remain in an adsorbed state. Or individual gases will remain in the coal layer in the porosity or porous structure of the coal. So, all these gases will remain inside the coal structure as individual gases, not as volatile material. So, as these gases are present in an individual state in gaseous form under high-pressure conditions. These gases will remain there for a longer time, and these gases are known as coal bed methane. That means these gases, which are rich in methane but can have other types of gases like ethane, propane, methylene, ethylene—whatever they may be—can be present there but to a smaller extent. So, they can be present in this gaseous mixture, which is called coal bed methane. That means this methane gas is stored in the coal layer. So, it originates from the coal or is generated during coalification, and it remains in the coal structure for a longer time. But they are present as individual gases. Now, these gases, whenever they get any chance to escape like a decrease in pressure or if the coal layer is cut down by mining activities all these gases will continuously come out depending on the pressure,

temperature, concentration of gases, and other physical parameters. So, these gases are known as coal bed methane. So, these gases typically, they are generated during the formation of coal.

So, during the formation of coal or during this coalification process, these gases are generated and they remain trapped inside the coal seam. They will be present inside the coal seam along with the water and other materials, other gases. So, this gas is known as coal bed methane. And this gas contains other types of impurities like H2S, ammonia, and other gases which are part of the original structure of coal. If the original coal has some sulfur components, nitrogen components, or chlorine components, all these gases in trace quantities will also be present in this methane gas. These gases, if methane gas is present, are always very risky for mining activities because during mining, these gases will continuously release from the coal structure. If this concentration is at a higher level or if it crosses the safety limit, then the mining activity becomes very difficult.

Unless we remove all these gases, we cannot continue with the mining activity because these gases are extremely hazardous and can cause fires. People can also die if the concentration of methane gas is too high. Typically, CBM is chemically identical to other sources of gases. If we see other sources of natural gases or methane gases like natural gas, naphtha, or whatever, this gas composition is very similar to natural gas composition. That's why it is sometimes called coal bed methane, which can also be used as a replacement for natural gas and others. But this gas is produced by non-conventional methods. These gases are not available at every location, only in some mines or sources where this coal or methane gas is present. This methane gas is not present in all the mines. That methane gas, whatever is there, can continuously come out from the coal structure depending on the porosity of the soil as well as other characteristics.

So, not all coal mines will have this methane gas, but maybe they have methane gas, but the concentration may be on the lower side. If the concentration of the methane gas present in this coal seam is on the higher side, then only we can extract it, collect it, and use it for different purposes. Typically, in this coal bed methane, more than 95% of the gas is methane. That is well known as the green gas. It doesn't contain any significant amount of sulfur.

Typically, if coal doesn't have any quantity of sulfur or if has very less quantity of organic sulfur, so all this sulfur typically converted to H2S. So, if the coal source has very less quantity of sulfur. In such case the released methane gas or the CBM will have very less quantity or almost zero quantity of sulfur rich gases. That's why it is called as the sweet gas or green gas.

CBM is a hydrocarbon in gaseous form. Its origin is from the coalification process occurring during the millions of years out of the plant. accumulated plant material and this methane gas as they are already in the very high pressure if they were in the gaseous phase stage, they can come out if they will be able to come out if the rock structure they are porous in nature as the rock is non-porous and inside the earth surface, there is high pressure. At this high pressure typically methane gas is almost in the liquid phase and it remains inside the pores within the coal called the matrix. So, it is present inside the coal structure or inside the matrix of the coal and the open fracture of the coal called the clits can also contain free gas and can be saturated with water. Sometimes above the coal mines, some there can have some vacant space or space is there which can also contain methane gas. Because if there is some gap between the coal seam as well as the rock, it contains may have some quantity of gases. And that also can be filled with water also. Unlike the natural gas in the conventional reserve, the methane gas or the CBM contains very little quantity of heavier hydrocarbons such as propane, butane and no natural gas condensate.

Typically, as it is going for continuous degradation process, so whatever the hydrocarbons present are there. There will be of lower molecular weight not any heavier molecular weight hydrocarbons like propane butanes will be there. So, it mostly contains methane 95 and some other quantity of ethane and similar type of gases will be there so coal bed methane contains variety of constituents like Methane gas, carbon dioxide gas, nitrogen gas, some water will also be there, some ethane can also be there and similar type of other hydrocarbons. And that's why this term coal bed methane is used, where it will have higher quantity of methane. And it often contains up too few percentages of carbon monoxide also. It may contain some carbon monoxide which is released during the coalification process.

CBM grew out of the venting methane from the coal seam. So, these gases will automatically come out of the coal seam as they are already in the high pressure. So, whenever this pressure is released, the gases will automatically come out of the coal structure. Now some coal beds are very known as the gassy coal bed and it is a safety measure borehole were drilled into the seam from the surface and methane allowed to come out before mining particularly if we see this aspect. There are several coal mines are there where this concentration of methane gas is significantly on the higher side.

So, if the methane concentration in this coal seam or coal mine is significantly on the higher side, that particular mine or that particular coal seam is called the gassy coal mines or gassy

coal seam. This term gassy means it contains large quantity of gases. So, this large quantity of gases is primarily rich in methane, but it can also contain other gases like carbon monoxide, carbon dioxide, hydrogen and other gases. So, if the coal mines have large quantity of gases which is absorbed on the coal surface, so whenever we open this coal surface or coal seam, that means whenever we start coal mining using any equipment or any from the top surface whatever the rock or other material is removed the pressure of the coal surface is get released and all the gases comes out.

Now, if all these gases come out and as they contain methane, carbon monoxide, and other gases, it is very dangerous to conduct coal mining activities as well as operate other equipment, which is also extremely hazardous. Because these gases can catch fire immediately at any time, as well as pose a hazard to human health, which is why such coal mines are called gassy coal mines. In the case of gassy coal mines, initially, all the methane gas and other gases must be released from the surface layer or inside the coal structure before mining activities can begin. And as these gases are already under high pressure, in the case of gassy mines, initially, this methane gas is allowed to vent before actual mining begins. So, as the pressure of the gases is on the higher side, it is always. Allowed that methane gas should come out. If it is coming out naturally, it is okay. If it is coming out in phases, we have to conduct mining activities in phases; otherwise, this methane gas is extremely dangerous and can damage the mining equipment as well as pose risks to human health. So, in the case of coal bed methane, whenever we insert a pipe for drilling or other purposes, these natural gases, whatever is present, automatically come out as they are always under high pressure. So, the intrinsic properties of coal, as found in the natural. So, nature determines the amount of gas that can be recovered. If the porosity of the coal is on the higher side, what is the pore size, pore volume, etc.

So, depending on all these properties, the quantity of gas that can be stored inside the coal structure is determined. So, it depends entirely on the properties of the coal. It is trapped in the coal bed and is released during and after mining when the pressure is released. That means these coal gases are already trapped in the coal bed. Whenever it gets a chance to come out when the pressure is released, it will automatically come out. The amount of methane present in coal seams increases with the rank of coal and the depth of the coal seam. Typically, if we observe the coalification process, only methane gas or natural gas is generated. So, with an increase in the coalification process, if we observe peat or lignite, it is not mature coal, and the coalification process has not been completed. In such cases, the methane gas or natural gas

present in this coal will be relatively less. But if it increases further with bituminous coal as well as anthracite coal, where the coalification process continues.

Methane gas will be released from the coal structure during this coalification process. A much higher quantity of methane gas can be present. That is why the amount of methane present will be much more. For higher quantities, it will be in high-rank coal, and for lower quantities, it will be in low-rank coal. Similarly, if we go deeper into the seam, the pressure on the coal layer will be higher because, at 100 meters or 150 meters, the pressure from the soil and other factors will be greater. So, a much greater quantity of methane can be absorbed on the coal surface. That's why a higher quantity of methane is available at greater depths of the coal seam and in higher-rank coal. CBM is a versatile source of energy that can be readily stored and transformed into alternative forms of energy, such as electricity and others. So, whatever methane gas is present, if we can collect and recover it, it can be used as an alternate source of energy, like natural gas or compressed natural gas. We can use it in almost the same way other gases that's why it can also be used as an alternate source of energy from the coal. This is the typical method how this coal is how this coal mines which contains methane gas is extracted, so if we see the deep coal bed here. So, in this deep coal bed it contains different type of gases like carbon dioxide, methane and other gases. Now whenever we do this put some pipeline inside there so in such case and if we put some inject some of the materials like other gases if we inject them in such case also this methane gas can go there and it can come out to other pipe. So, if the pressure of the methane gas is on the higher side they will naturally come out if pressure is on the lower side we can inject other inert gases like carbon dioxide nitrogen gas etc. So that this gas pressure on the methane gas or this coal slayer is on the higher side, so that methane gas can comes out so it can automatically come out if the pressure is on the higher side if the pressure is on the lower side we have to put some external pressure. So that the gases which is available in the coal surface they can come out. So, to extract gases, typically a steel encased hole is drilled into the coal seam, which is typically from the 100 meters to 1500 meters. So this coal bed methane is available far below the earth's surface so 100 meters is very smaller length where coal may contain some methane gas but typically we have to go for longer depth maybe 1 kilometers or 1.5 kilometers that is 115 meters or more than that so typically may we have to go even up to 5000 feet we have to drill the hole using the steel encased pipeline at the pressure where the coal seam declined due to natural production of the pumping water from the coal bed both gases and produce water come out through the surface during so if you go inside this coal seam and if we put some pipeline there so in such case the coal seam gets the

pressure is released because initially the rock layer was there which was creating some pressure but whenever we put the pressure we put the pipeline. So, all the gases they can get that pressure is released so whatever the methane gas is there as well as whatever the water is also stored in this coal seam along with the coal which is known as the produced water, so both gas this natural gas as well as produced water they come out so the tubing automatically as they are already in the high pressure like if this is the coal seam. So, at this location if they are supposing at high pressure of 5 bar, so due to this 5-bar pressure they will automatically come out through the tube lines then the gas is sent to the compressor and we get the natural gas pipeline we can get it. It may have to go for some cleaning on other purpose to maintain the quality the produced water whatever is coming out from the coal seam they are either re-injected in the isolated formation because this produced water whatever is coming out of the coal seam it may contains different type of hydrocarbon rich materials. So, it is not a pure form of water, it contains different type of impurities and some of the impurities are harmful. So, in most of the cases, this produced water is again re-injected in the coal seam so that it can go there and it can be safely be discharged there. But in other cases, if this quality of the produced water is satisfactory, they can be released to the streams, the rivers and used for irrigation and sent to the evaporator, etc. So, it depends entirely on the quality of the produced water if it is contains some different type of impurities it needs to be treated before discharge to the water bodies or other or may be kept it in some evaporation ponds where it will continuously get evaporated by the sunlight so this water typically contains different type of dissolved solids such as sodium bicarbonate chloride but varies depending on the formation of geology so this produced water whatever is coming out from the coal seam, along with the coal bed methane, it may contain different types of salts, organic compounds, and others. So, after verification of all the properties, whatever materials are present in this coal seam, they are purified or may be discharged into water. So, it entirely depends on the coal seam where it is present, the types of rocks, and other materials. So, if we see another picture here. So, this is the layer where coal bed methane is available in this coal layer.

So, if we put some pipeline there, it will automatically work, and if we put some pump there also. So that if we put the water to go there, in such cases, whatever gases are there, they can come out. So, in this path, we can get those gases to come out, and in this path, we can get that through some pump we can extract the water. So, if we extract the water, in such cases, the pressure inside this coal seam decreases significantly, so the natural gases can come out through another pipeline. So, there will be two concentric pipelines to install. In this inside pipeline, we

will get that water to come out through this pipeline. We can pump it to the other side, and we can also get the gases that will come out, which can go to the pipeline. Similarly, if we see the depth in the detailed other cases, there are two concentric pipelines here. In this pipeline, we can get the methane gas, whereas on the other side, we can get the water gas. So, we have two waters. So, we have to drill the coal mines such that initially the shale layer, sandstone, coal, coal bed methane, all will be present there. So, we have to reach to drill a pipeline to this depth now if the porosity of this sandstone shell are highly porous this methane gas will naturally come out in such case concentration of methane here will be very less but if the porosity of this sand shell or sandstone is zero that all the gases will remain intact in this layer then whenever we drill this or we put this pipeline this gases and water will naturally come out If the velocity of water is not adequate, we can put some pump so that all these gases comes out and along with water comes out of the coal structure. So, if we see that coal bed methane wells are often produced at lower gas rate. then conventional reservoir if we see the conventional reservoir of natural gas in such case the concentration of methane gas is significantly higher but in case of coal bed methane the concentration of methane gas is not up to that level because in case of natural gas reservoir the concentration of methane gas is significantly higher as in the case of coal bed methane it is one of the byproduct not the major product it is the major product is the coal already present in the coal mines or coal seam.

So, it is only the byproduct of the coal bed. So, this concentration is on the lower side. So, typically its peak concentration may be 3 lakhs cubic feet or that is 8500-meter cube per day which is on lower value that is about 0.1-meter cube per second velocity it can come out. And it can always have the large initial investment cost to install all these facilities. The production profile of CBM wells is typically characterized by a negative decline in which gas production initially increases. we pump the water up and gas begin to dissolve and flow and dry CBM oil is very similar to a standard gas oil. Typically, the production of CBM is initially on the higher side. Now once this the water is removed from the gas layer and we continuously remove this methane gas, the production of gas level always goes on the negative side. The same picture here we have seen is the water and coal bed methane are there. So, we can get the water through the discharge here and we can through the other pipeline we can get the methane in this layer and we have to put one submersible pump at this layer so that this can continuously pump out the water present in this coal seam. So, typically coal suitable for CBM, it will have the following characteristics like it should have higher amount of gas content. So, if we have to identify whether these coal mines or coal seam has some quantity of methane gas, typically

coal characterization is done. Coal characterization in terms of coal other properties is done. That is if the gas concentration is on the higher side that is varies between 15 to 30 meter cube per ton then only it is suitable for the extraction of coal bed methane because if you want to install some plant concentration of methane gas has to be on the higher side so if the gas content is above 15 meter cube per ton then only if economically it is possible to extract the methane gas similarly the gas permeability must be above 30 milliliter seam and 250 milliliter seam and above so that coal seam has very good amount of pores and other structure, so that these gases can automatically come out from the coal stream and typically the coal seam which are less than thousand meters in depth, so the such type of pole seam are only suitable or where we can find coal bed methane in some higher quantity the pressure at greater depth is often too high and allow gas to even when the seam has been completely dewatered if we go for the high depth or greater depth coal seam gas can automatically come out this is because that high pressure causes the create the structure of the clothes and reduce the permeability and most CBM projects produce gas from the bituminous coal but it can also be available from the anthracite coal in some cases now CBM resources in the Indian locations is about 92 trillion cubic feet in 12 states of India and Government of India has formulated whole bed methane policy particularly giving it to the natural gas companies like ONGC and others where the CBM is being natural gas in exploited by under the provision of Oilfields Regulations Act and which is controlled typically by the Ministry of Petroleum and Natural Gas. And the Gondwana sediments of eastern India host the bulk of India reservoir and also current CBM projects producing blocks. So already to extract this coal bed methane to a commercial level, government of India has already formulated policy. They are giving tenders to different companies so that this coal bed methane can be extracted from the coal seam to use it for our, to meet our internal energy demand. and most of the coal bed methane are developed are in the eastern India particularly in the near field of Damodar river valley and the Son river valley most of the coal bed methane are available whatever it has been observed till late they are near by the Damodar valley and the Son valley in the Damodar valley where the coal concentration is significantly higher directly coal is extracted whatever the if the coal is available in the top surface then coal is extracted by the direct method. But in some of the location coal is available but below the depth of 1 km and more. So, in such cases at present condition extraction of coal is not feasible or it is too much costly. So CBM projects are already installed in such locations particularly in Raniganj south, Raniganj east, Raniganj north area, in the Raniganj coalfield, Parbatpur block in the Jharia coalfield and east and west Bokaro coalfield. So, in all these coalfields, wherever the coals are available at the longer depth.

So there this coal bed methane is being extracted or the plant are being installed. to extract this coal bed methane and similarly the Son valley includes Sonhat North and Sohagpur East and West blocks. Also, currently commercial production has been started in the Raniganj coal block as this is the new source of energy and concentration of methane is there but not on the significantly on the higher side. So, government is taking some time to giving tender to the different companies who are interested to extract this methane gas from the different locations. So already this coal bed methane extraction has been started in different coal blocks of the running on coal field areas and for the other areas already it is in process and we can get coal bed methane from all such sources. And if we see that India is one of the prominent energy players where we can get the CBM market with as many as 6 to 7 CBM fields are either producing or in the verge of production and estimated domestic production will be was in the 2017-18 was in the one CBM and it will rise gradually in the next year and it is expected that coal bed methane will contribute about to five to eight percent of the energy gas production by next few years and the country has identified many large areas like 26 000 square kilometer area for CBM and total estimated CBM reserve is about 2600 cubic meter now whenever if we see this CBM or coal bed methane is available this coal bed methane must be extracted from the coal seam so that at a later stage or after a span of 10 to 20 50 30 years this coal can be extracted by safe manner. If any coal mines or coal seam has large quantity of methane, so there must be at initial stages the CBM plane must be installed to extract all the coal all the methane gas present in coal. So it fulfills that initially we can get the methane gas and later we can safely extract this coal by conventional mining or any other mining technologies Now, this full bed methane can be used in different applications as the concentration of methane gas is high and if the quantity of methane gas or volume percentage of methane gas is on the lower side, this methane gas can be used for domestic purpose where the low calorific value or lower volume of gases is required as well as this methane gas also can be used for the fertilizer production and other purpose.

So different companies are already working on this to install or supply this coal bed methane gas, either for domestic cooking or domestic heating, or low-temperature heating purposes, as well as for the production of fertilizer and obtaining other types of byproducts from this methane gas.

Thank you.