Waste to energy conversion
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Lecture – 18
Densification of solids – 1

Good morning everyone now will start a new module densification of solids. In the last modules we have discussed on different thermo chemical conversion processes like incineration, gasification, pyrolysis etcetera and we are seen that uniform feedstock properties are very very important to get better performance of the process, and we have also seen that in this processes some pre treatment step is required which requires the feed materials to have some mechanical stock resistance properties.

Thus any solid materials having uniform properties like higher density, uniform particle size etcetera and is very very important for the getting more efficiency of the process. So, densification is has a process which imparts this properties to the biomass and waste which is available in nature. So, this biomass and waste available in nature are not having these properties. So, densification helps to improve the uniformity of the properties as well as it gives uniform particular size.

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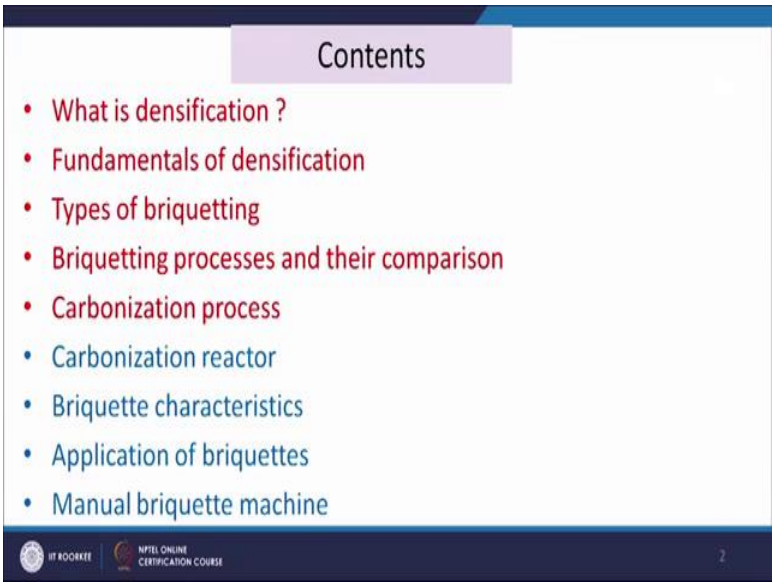

So, in this module we will see what is densification, fundamentals of densification, types of briquetting, briquetting processes, and their comparison carbonization process

carbonization reactor, briquette characteristics, application of briquettes and manual briquette machine.

So, when the briquettes are formed then those are used for further applications like incinerations or gasification, but as such if it is used then it produces a larger amount of smokes, that is why that carbonization is followed to reduce the smoke or fumes less production as well as to improve the fuel quality of the material.

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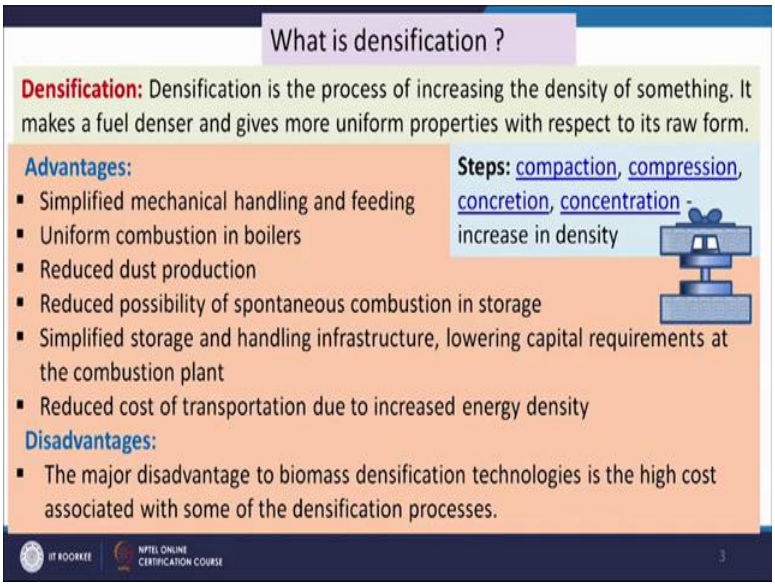

Now, let us see what is the definition of densification? So, densification is the process which increases the density of any material; when it is applicable for fuels that increases the density of the fuel as well as it give some uniform properties like uniform particle size the higher density etcetera.

So, what are the advantages of this process? The advantages are that this is simplified mechanical handling and feeding, and then uniform combustion in boilers; when the briquettes are used in boiler then due to their uniformity in properties like particle size the combustion is more efficient. So, that is why uniform combustion in boilers reduce to dust production as the smaller particles are not available in this material. So, reduced in dust productions and reduce possibility of spontaneous combustion in storage simplified storage and handling infrastructure lowering capital requirements and the combustion plant and reduce cost of the transportation.

As the material it becomes dense. So, the energy density increases that is why the reduced cost of transportation due to increase energy density, but this process has some disadvantage because it include some cost for the productions of the briquettes. Now let us see how the briquettes can be produced. So, for the production of briquettes at fast the particles are compacted, then it is compressed and then concretion and then finally, we get the concentration of the particles and we get the densified material. Now let us see the mechanism if we take some materials solid material it will be having some particles in it.

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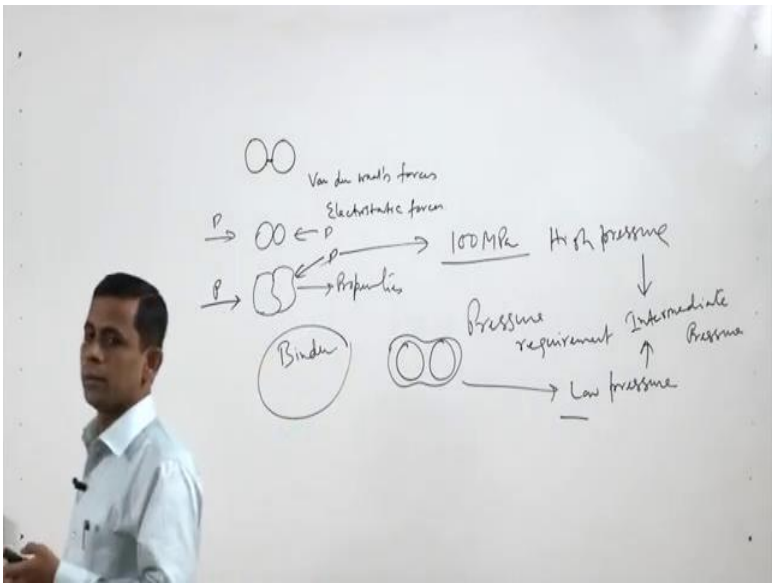

So, those particles will not be very close to each other, but it will be maintaining some distance all though they will be having some interactions, but there will be some separation between these 2 particles, and this is due to the Van Der Waal's forces or electrostatic attractions; electrostatic forces. Now if we increase the pressure then the particles will come closer this particle will come closer. So, distance will be this will be reduced further if we increase the pressure then the particles will be interlocked. So, particles will be interlocked this interlocking will depend upon; how efficient this interlocking is that will depend upon the properties of the particles means what is the composition of this particles if this particles contains a ligneous material.

So, this will be more stable, otherwise this particles again will try to springing and to be separated from each other that is why some binding is introduced. So, some binders are used so that the particles which are being interlinked will not be separated.

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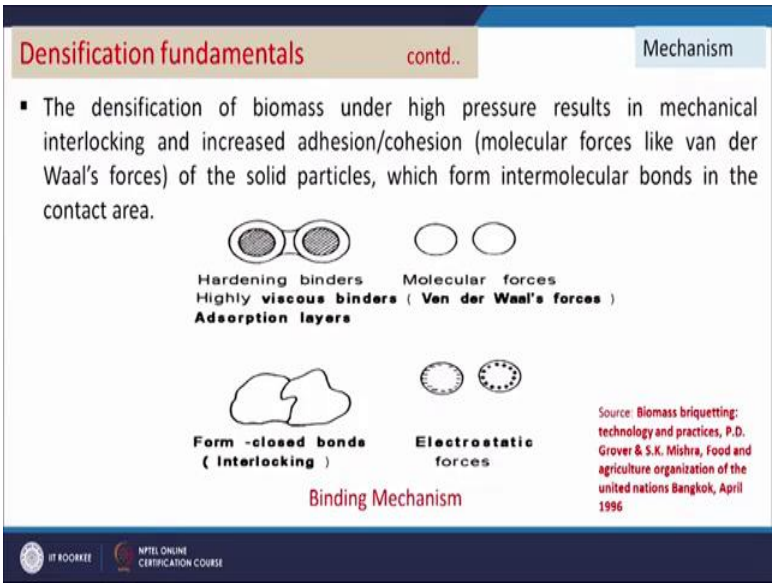

So, for the productions of briquettes we can see we need to put high pressure so that the particles will come closure and will be interlocked, or we can add some binders. So, some materials are there for which binder is essential the some materials are there if we apply high pressure binder is not required, and the binder helps to bind the particles and keep them close.

That is why in this process the pressure requirement is not so high. So, now, for this clogging interlocking purpose what should be the pressure range? That is around mega Pascal in many cases or more than this. Now we are getting 2 situations here we are having high pressure and another in case low pressure. So, the briquette formation can take place either in high pressure condition or in low pressure condition or in between there will be some intermediate pressure, pressure conditions. So, this is the mechanism through which the briquette is formed.

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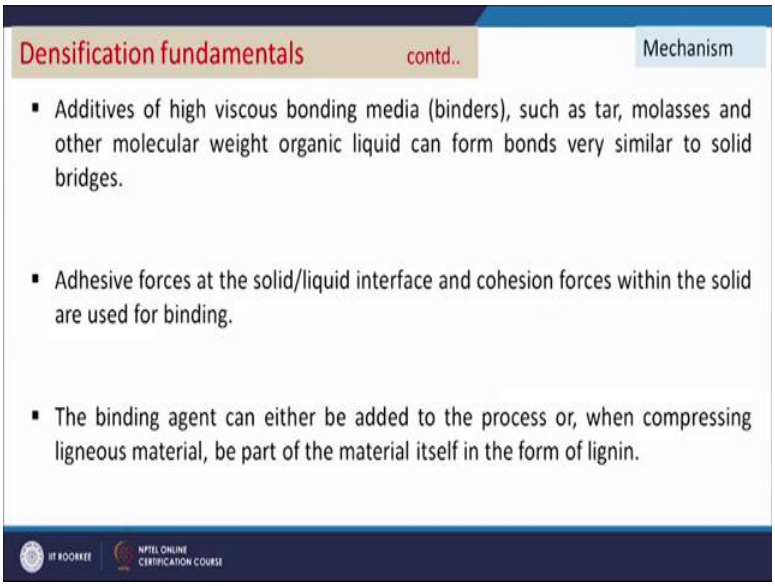

Now, let us see some information here the some additives which are added here those are may be organic or inorganic in nature like say tar molasses and other higher molecular weight organic compounds can be used, and this additives which binds these particles by the cohesion and addition. So, cohesive forces among these solid particles and adhesive forces between solid liquid particles, they bind the materials or the particles of the materials. And when the high pressure is applied lignin present in the biomass and waste comes out and helps for the binding. So, that is the ingenious binder. So, lignin present means the lignins will come out at high pressures and it will help for the binding, otherwise we have to add some external binding agents like see molasses tar or other organic molecules.

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So, the densified material which is formed through this densification process may be either in briquette forms or in pellet forms. So, briquette and pellets are separated on the basis of their diameter, but there is no very sharp distinction where normally if the 30 millimeter or less diameter then it is called pellets, and if the if the size of the particles are more than 30 millimeter then it is called briquettes. So, as shown here this this is the example of briquette and this is the example of pellets.

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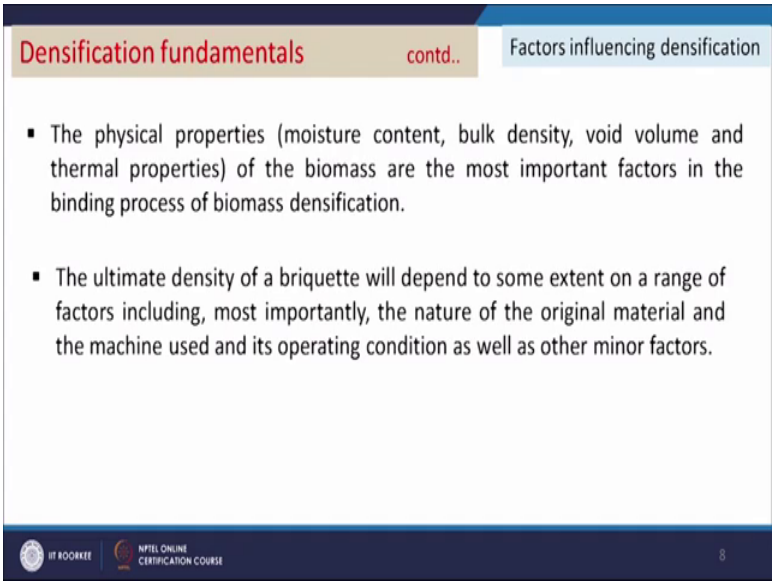

Now, there are some factors which influence the performance of the briquetting process. So, those are out of those some important are physical properties that what is the moisture content, what is the bulk density, what is the wide volume, what is the temperature the thermal properties. So, all those things will influence the performance of the briquetting process.

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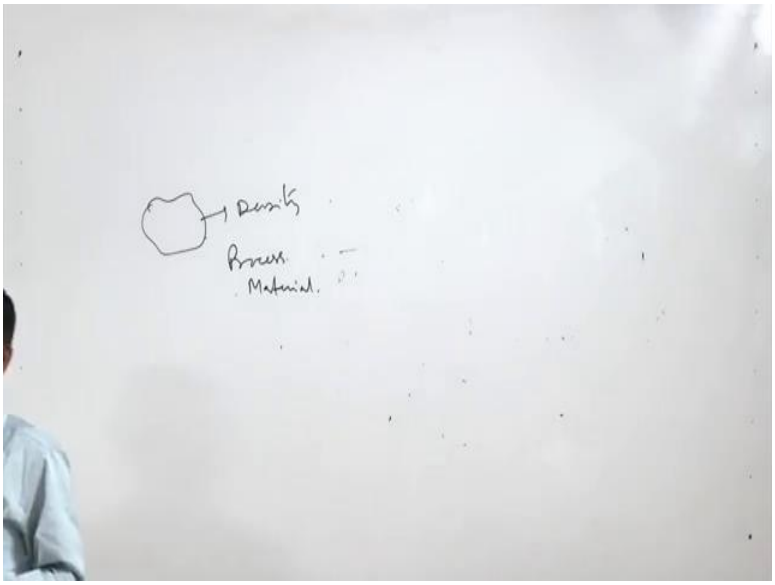

And ultimately after briquetting what will be the density, what will be the density of the briquettes that will be guided by the process used whether it is high pressure or low pressure or type of material. Some other factors are also there, but these are 2 are major factors which influence the final density of the briquette; now we will see how many types of briquettes are available or can be briquettes can be produced.

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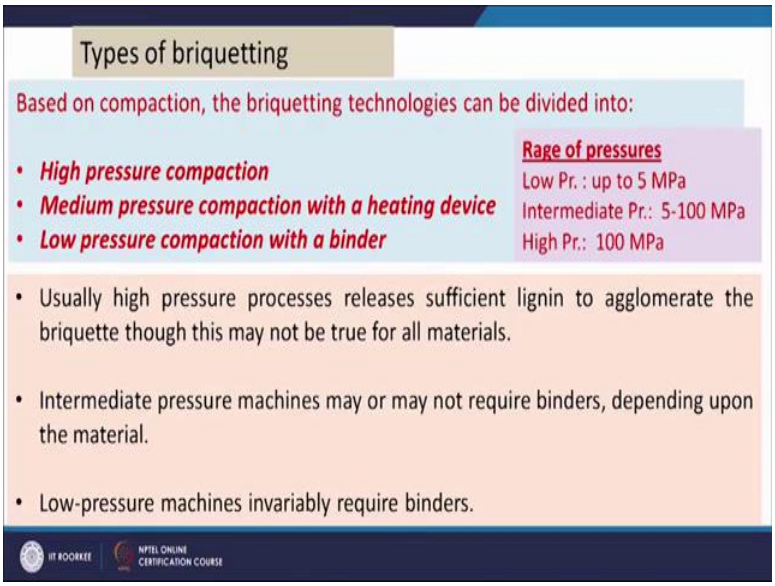

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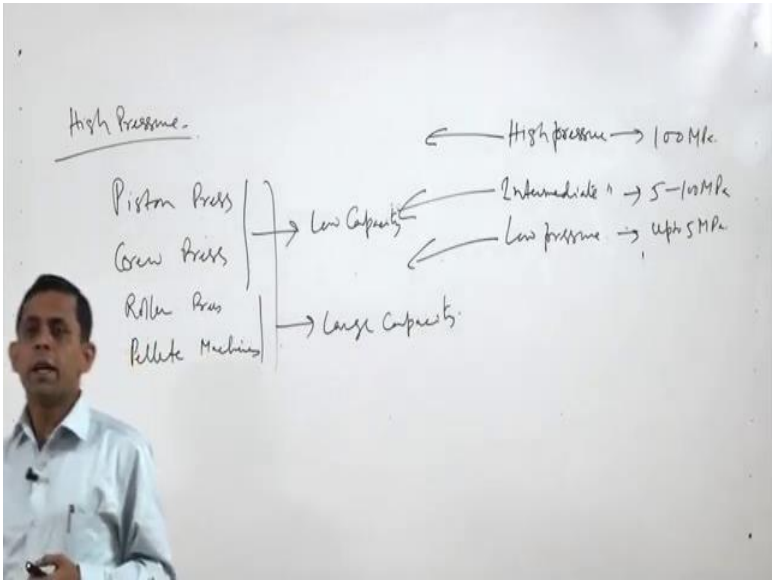

So, we have seen that high temperature high sorry high pressure, high pressure what is the high pressure around 100 mega Pascal or more than this. Intermediate pressure that is 5 to 100 mega Pascal and low pressure that is equal to up to 5 mega Pascal, these are the 3 ranges of pressures. So, how much pressure we are applying depending upon that we will get 3 types of briquetting process. So, high pressure compaction this high pressure compaction will not use any binders.

If the material having sufficient lignin so, the indigenous binders will be generated and they will bind the particles; low pressure will obviously, require binder and intermediate pressure process may have binder or may not have binder. Now we will see different types of machines which are used for the briquetting or for the solidifications of the solids of the biomass and waste. So, at first we will consider the high pressure case. So, high pressure normally four types of machines are used for the production of briquettes, the first one is piston press, second is screw, and third one is roller press, and forth one is pellet machine. So, these four types of machines are used for the production of briquettes, but these 2 are having low capacity and these are having very large capacity.

So, in developing countries where the application of densified materials is not very high in that case piston press and screw press are widely used. Like in our country the briquettes are normally used in domestic sectors and some very less in industrial sectors. So, this piston press and screw press are mostly used, but roller press and pellet machines those can be used for large capacity.

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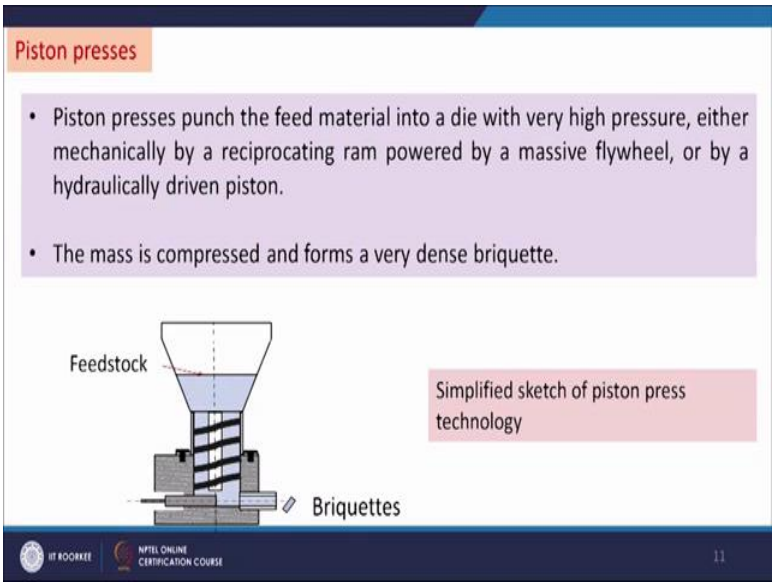

Now, will see how the piston press works? Now see in this slide we are seeing here one piston press. So, material feed is put here the feed is put here in passes through the necks and comes in this position, and this is the piston this piston have forward and backward movement.

That is why mechanically by reciprocating ram forward by a massive flywheel or by a hydraulically driven piston. So, this piston give some backward and forward movements of the particles or the solids which is coming from the top, and then it is placed there is some die. So, this dies present here. So, high pressure is generated due to pistons and this pistons keeps generates the highest density briquettes. So, this piston press produces very high density briquettes very high density briquettes now let us see, but one disadvantages is that this method cannot be used for a continuous productions, means only when it will your reciprocal movement will create the briquettes not continuously.

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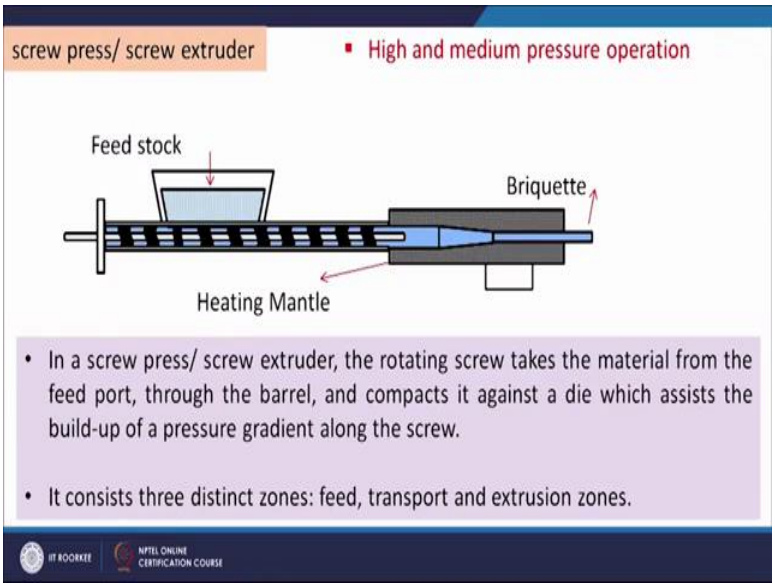

Now, we are coming to screw press or screw extruders; we see here one diagram schematics of the screw extruder. So, feed materials enters into the screw. So, the screw has some shaft which is rotating, this is the shaft it will rotate and due to the rotation the material enters into the screw will get some velocity and it will move forward it will move in forward direction.

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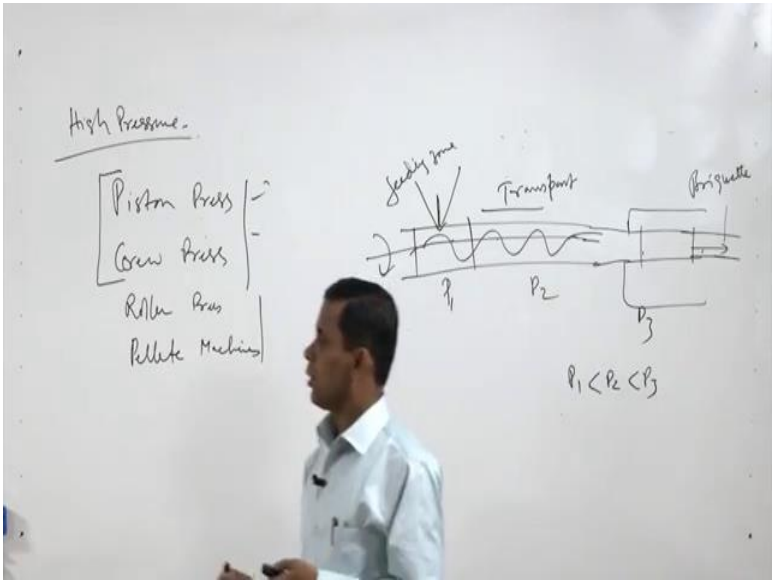

So, if it is our screw if it is our screw shaft. So, the material is coming here. So, this is some movement. So, this will come and will be having here some die we are having some die. So, when the material is moving in the forward directions, the pressure is generated. So, there is a pressure gradients say P 1 here is P 2, here is P 3.So, P 1 is less than P 2 is less than P 3.

So, high pressure is generated here and the die is there. So, from the outside of this we will get the briquette, we will get the briquette. So, here we get 3 zones the first is your feeding zone here, then this is your transport zone this is your feeding zone, and this is your compaction zone or we can.

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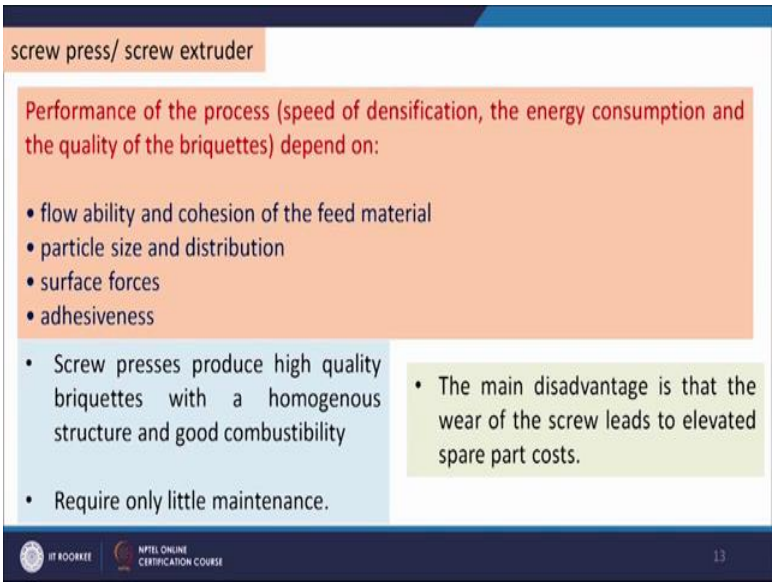

So, this is the mechanism of the production of the briquettes to the screw press; now how the performance of this screw process screw press is dependent, how this performance can be influenced. So, the performance depends upon flow ability and cohesion of the feed materials. The feed materials which is used here what is the flow ability and what is the cohesion properties particle size and distributions.

What is the particle size and distribution of the materials surface forces, and adhesiveness of the materials? So, this is the properties which will influence the performance of the screw conveyer, I mean the screw press the advantage of the screw press is that it produces high quality briquettes, but disadvantages is that that the weight of the screw leads to elevated spare part. So, cost of the spare part is high. So, this is the drawback that it requires little maintenance. So, this is all about your high pressure processes or different machines used for high pressure briquette formations, but if you think about the low pressure briquette formation then these machines will not be used low pressure machines

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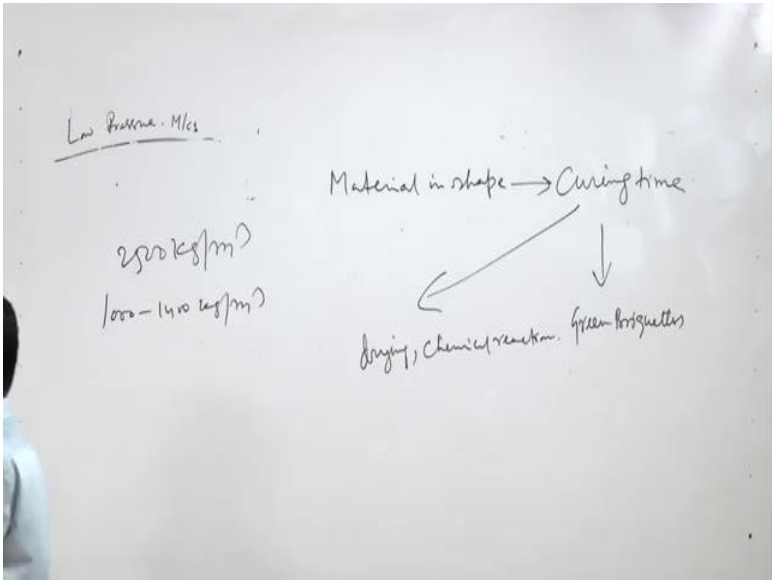

So, as we have discussed that for this case we need to add binders and the binders may be of organic or may be of inorganic in nature, organic binders like bitumen, coal tar, molasses resins.

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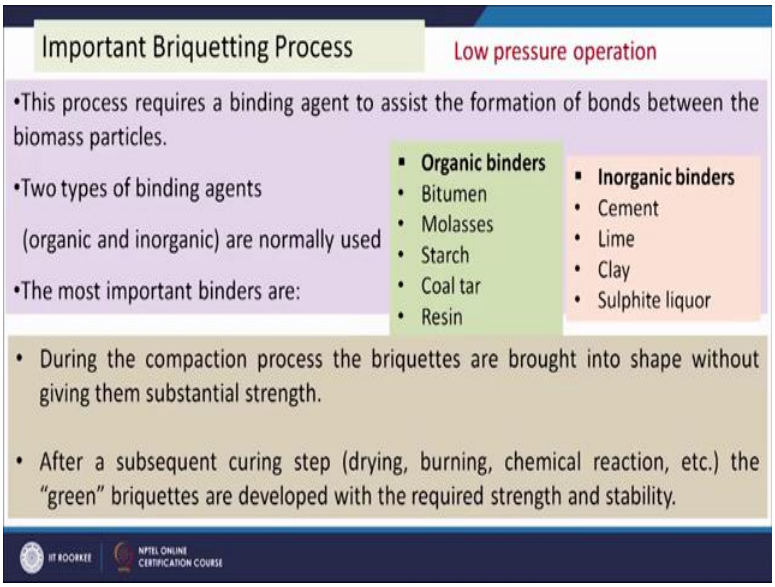

And starch etcetera and inorganic binders like cement, lime, clay and sulphite liquor. So, anyone of these binders can be used or the mixture of the binders can be used with the biomass and waste, and it can be put inside the machines. So, will get the briquettes, but in this case the main difference between the high press high pressure and low pressure

processes is that, in this case during compaction process the briquettes are brought into safe without giving them substantial strength.

So, first step we bring the materials in shape, and second step we give some curing time and it gives us green briquettes. So, what do we mean by curing time? Curing time means we are giving some drying time it is drying or some chemical reactions or binding. So, these things are done.

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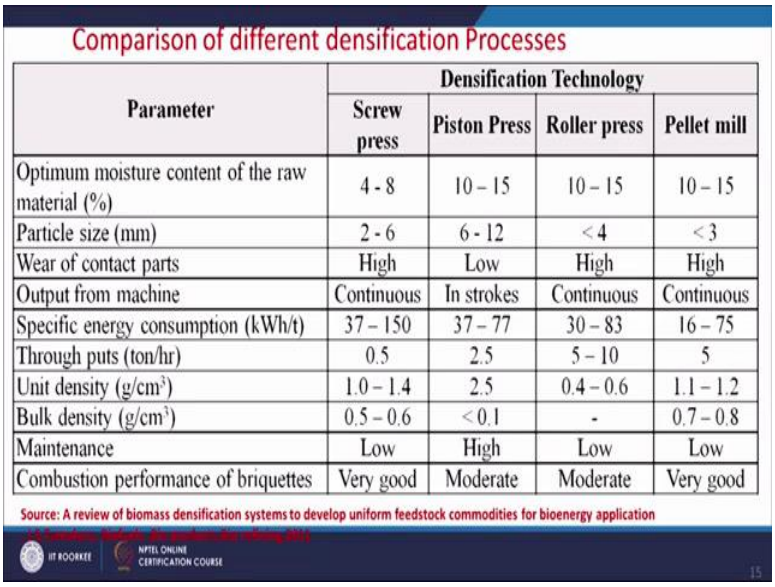

Now, we will see the comparison of difference densification processes. So, here screw process, piston press roller press and pellet mill. So, this four types of mills have been compared, all though these 2 are use for low scale productions and these 2 are for higher scale productions.

We see here the throughput for screw press is 0.5 ton per hour and this is equal to 2.5 ton per hour for piston press whereas, roller press is 5 to 10 and for pellet it is 5. It is very clear from this table that the operating conditions like optimum moisture content are different for different machines, particles size is different for different machines, wear of contact parts is also different, the screw is having the highest wear of contact parts as we have just discussed. Output from the machine in except piston press for all the other cases will get continuously, and specific energy requirement that is very very important factor the specific energy requirement.

We see it is very high for screw press and the low very low in case of pellet mill. So, bigger the capacity we are having the lower specific energy consumptions, but the limitation is that whether we will be using the briquettes; if everything is in systematic way we have good demand of the briquettes we can go for this pellet machines where the energy requirement will be less, otherwise we may opt for these two. So, our main objective of this densification process is to increase the density of the material. So, we compare the unit density we get here maximum density in case of piston press that is 2.5 gram per centimeter cube that is your 2500k g per meter cube.

But in case of screw press it is 1.0 to 1.4 gram per c c that is equal to 1000 to 1400 k g per meter cube, but in other cases we see in case of roller press it is less and in case of pellet mills it is also less. So, these 2 gives us higher quality and bulk density in case of screw press it is 0.5 to 0.6 gram per c c whereas, piston press is 0.1 or less than this, this is very important factor or information due to the piston press it gives maximum pressure and. So, highest density material is used that is why your bulk density is decreased, and maintenance is also different for all types of mills.

And combustion performance of the briquettes is also different we get very good combustion for the screw press, and for the pellet mills and for these 2 piston press and roller press the performance is moderate. Now we have got the briquettes then what will do with it that will be used in either combustion or gasification or some other applications.

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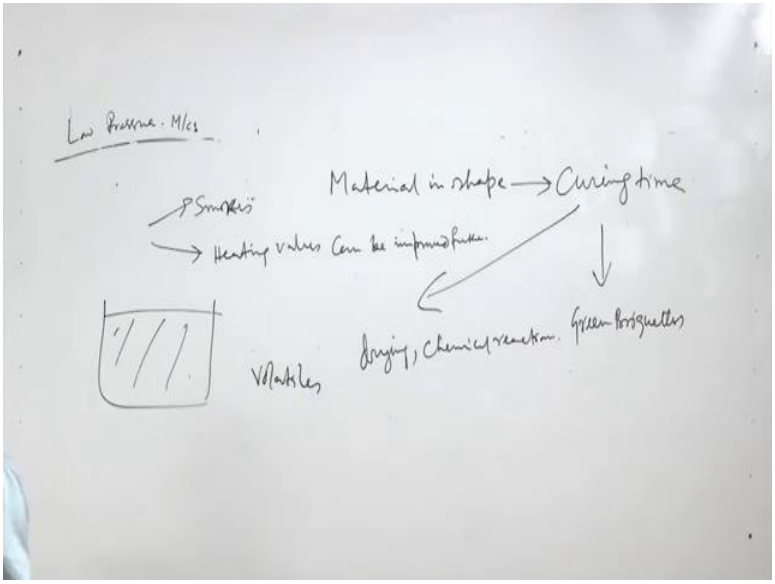

So, when it will be used for further applications in case of combustion it will give more smokes just we have discussed; and this the heating values can be improved further.

So, the briquettes if we use as such it will be having some disadvantages, those are reduced ignition and burning properties, low heat value and not stable underweight conditions. The briquettes cannot be stored under moist condition for a longer time that is the disadvantage. So, these major disadvantages of the briquettes can be removed by its carbonization, as you have seen in pyrolysis module that carbonizations improves the carbon content in the material and it gives also higher heating value and it removes the volatiles. So, carbonization of the briquettes will also help us to make it more carbonaceous and to reduce its volume and the volatiles which will be produced for the productions of carbonized briquettes that can be used for the heating required for the carbonization process.

Partially actually it is heated at 600 degree centigrade when it is treated as 600 centigrade. So, partial pyrolysis takes place. So, the vapors come out. So, this volatiles contain some combustible gases like CH4, acid formic acid organic acids etcetera or it may contains C o 2 it may C o etcetera. So, different gases it may contain H2O may also available with these things with the gases. So, this volatiles this can be used for heating purpose for the production of the carbonized briquettes. So, the carbonization when and

how we will do this is a big question; we have biomass and waste intermediate product is briquettes, and then we are getting carbonized briquettes.

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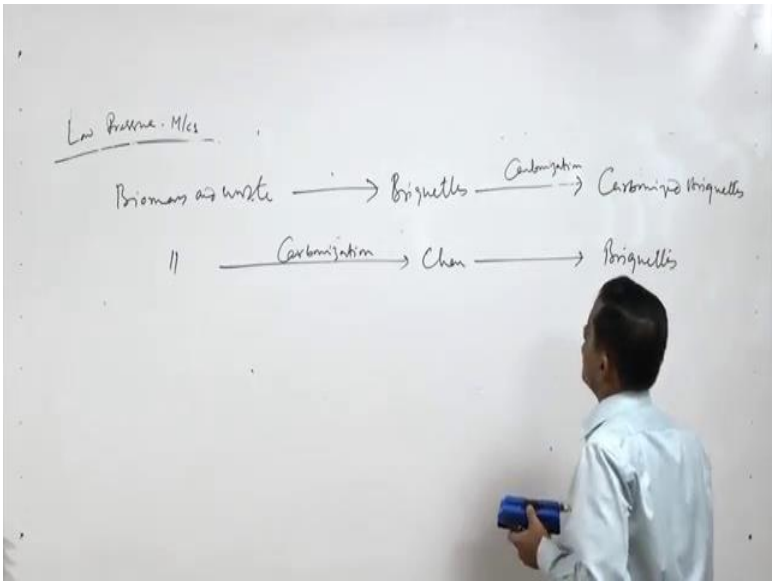

So, one option biomass and waste we can make briquette then carbonization, carbonized briquette. Carbonized briquettes or biomass and waste you do here carbonization then carbonized biomass or char. So, this char we can make briquetting. So, briquettes, now, these briquettes can be produced from directly from char or char plus biomass also. So, we have some flexibility anyone options we may adopt.

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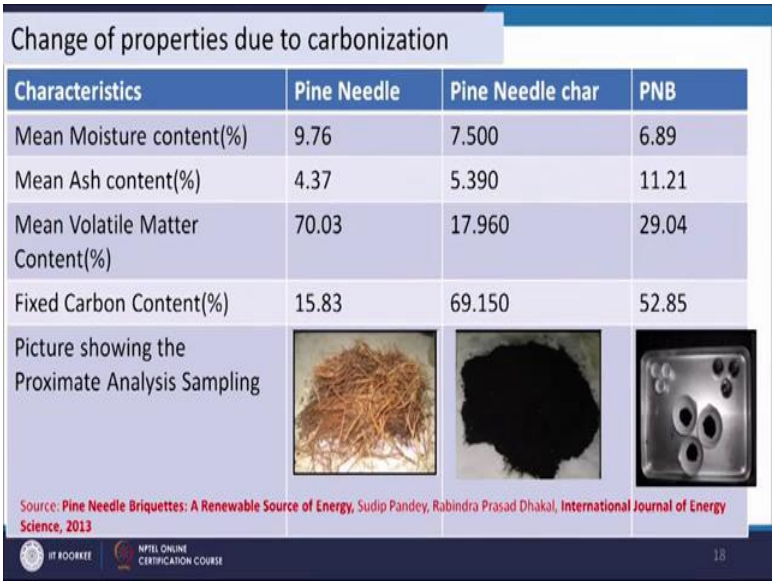

Now, I will show you some example, how the property changes due to the carbonization. So, with reference to pine needle, and pine needle char and pine needle briquettes, we see here we are able to achieve intermediate properties in the briquettes.

So, some pine needle are shown here some pine needle and pine needle char we can add in certain ratio and make briquettes so that we can get intermediate properties. So, this is the technique through which we can monitor the properties of the briquettes by monitoring the compositions of these 2, for the productions of the briquette. So, you see here the carbon content in pine needle is 15.83 percent, pine needle char is 69.15 and for pine needle briquette it is 52.85. For other cases this is applicable like for mean moisture content ash content and volatile matter content.

So, up to this we have seen that different types of briquettes, the fundamentals of briquetting and the carbonizations and briquetting of the biomass and waste and when which can be done and how the properties can be monitors. So, up to this in this module and the second part of this module will discuss on the rest of the contents.

Thank you very much.