Waste to energy conversion
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Lecture – 19
Densification of Solids – 2

Hi friends, now will start discussion on the second part of the module Densification of Solids. And in this module we will cover carbonization reactor, briquette characteristics application of briquettes and manual briquette machines.

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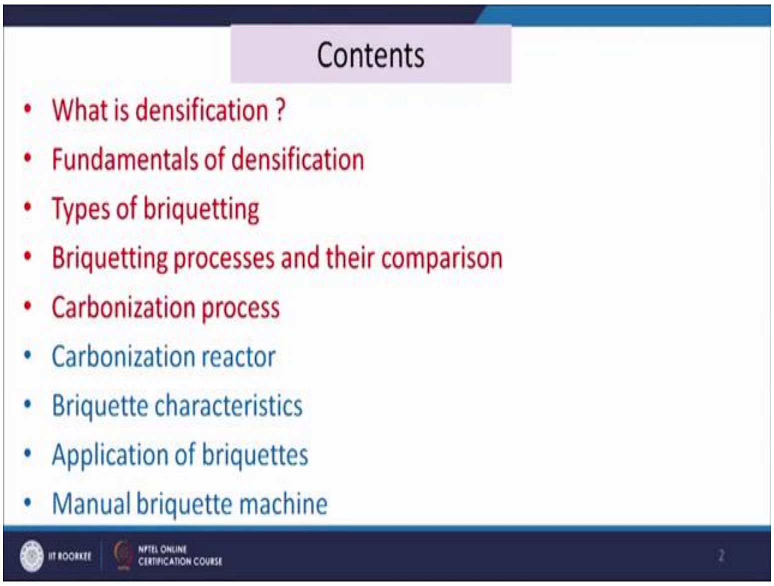

Now, we will start with carbonization reactors. Just now we have discussed in the previous part of this module, that carbonization is necessary to improve the fuel quality of the briquettes. And for this purpose we have basically 2 types of reactor depending upon the type of the material.

If the material is course material of medium size, then we go for shaft furnace continuously working shaft furnaces. And if the material is a fine then we will go for rotary skills or stationary vessel equipped with a staring device. For a example screw feed. So, this vessel are heated externally either by the combustion of any fuels or the off gasses which is generated during the carbonization process that can also be used. Now let us see the working of carbonization reactors that is continuously operating shaft furnace. So, here we put feed this feed material enters into this reactor zone through these 3 columns.

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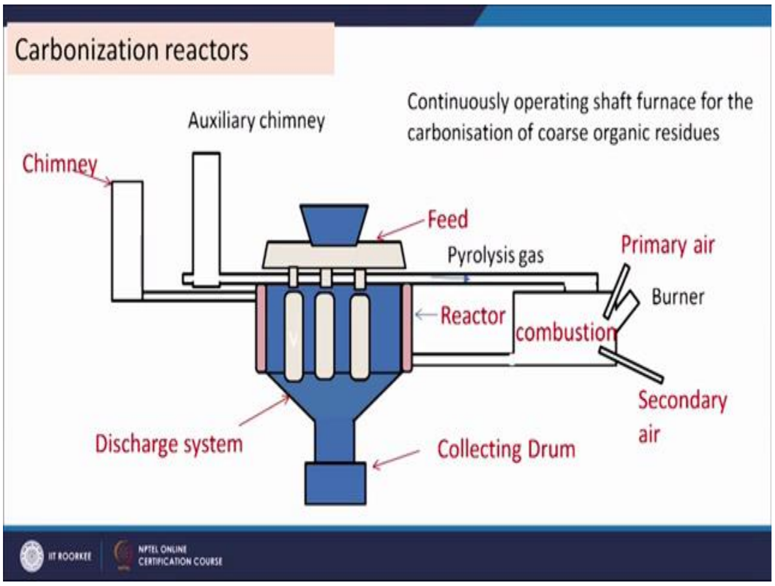

Here 3 columns have been showed these are the passage of the solid particles this we will go through this columns, and this is inside in this reactors this is hollow chambers say. So, here we are combusting some fuels here at the initial stage we will combustion fuel here then gradually the flue gas will go to this reactor zone and will raise the temperature here. So, all those columns temperature will rise. So, this material when is passing through this columns, those will be heated up and volatilization will take place volatized material will goes off and will come through this line that is paralysis gas.

So, off gas will be sent to this combustion zone. So, that we it can be combusted further to produce flue gas and release heat that heat will be used again and after this combustion the flue gas after raising the temperature will go through this chimney to the environment. And this is another emergency chimney or auxiliary chimney is there, if needed to release the paralyzed gases. And from the bottom we will collect the carbonized material. Now the question is this is suitable for course materials if pines materials this will not be suitable. Because we see here we put the material that is coming through some channels.

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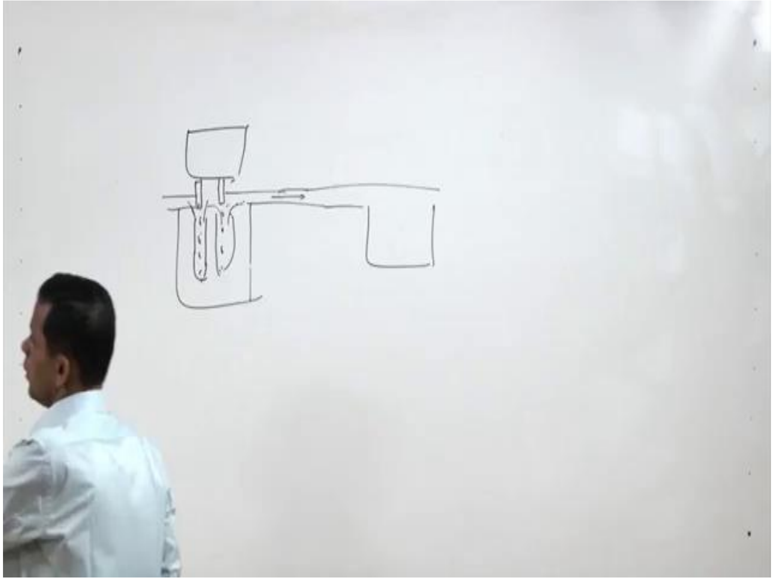

So, if there is some bigger size materials that will flow inside it, but if the pines are there. So, off gas which is generated during heating inside, that will also goes off and it will come through this channel and back to this combustion chamber, pine materials will not be able to go through this rather it may be carried over by the gas generated during the paralysis process. That is why this is suitable for course and bigger or medium sized particles. Now we will see the characteristics of briquettes. How can we define a briquette is good quality or inferior quality? There are some characteristics on the basis of which we can access the quality of the briquettes.

So, those qualities can be grouped into 2 categories: one is related to briquette handling characteristics and another 2 related to its fuel characteristics.

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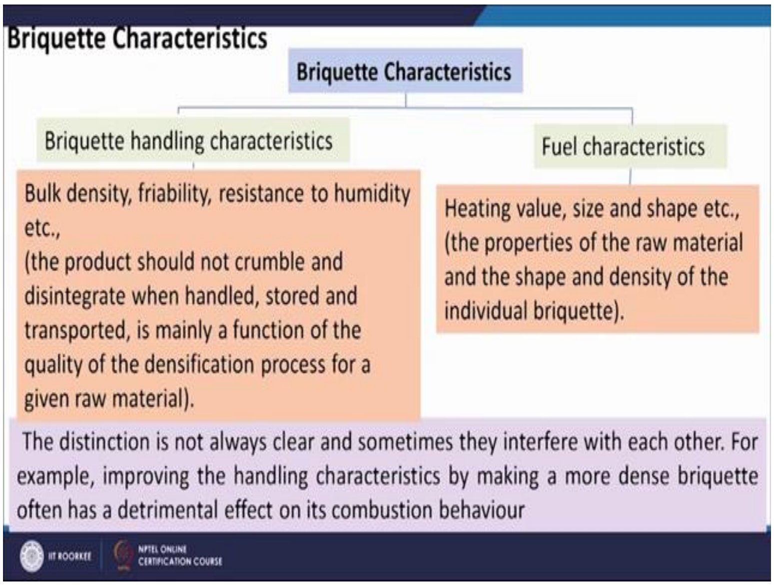

So, briquettes handling characteristics means it is density it is friability and resistance to humidity bulk density friability resistance to humidity. And fuel characteristics are heating value and particle size and shape. Now we characterize the characteristics it to categorize, but there is no way by distinction between these 2 and it may be possible that if we want to achieve one property very high the other property may be affected like for example, say if we make very hard briquettes.

So, that it is handling will be very easy, but that briquette may give us less heating value. Now we will discuss all this properties one by one. At first let us discuss the density. So, density in the previous modules we have seen that for screw press.

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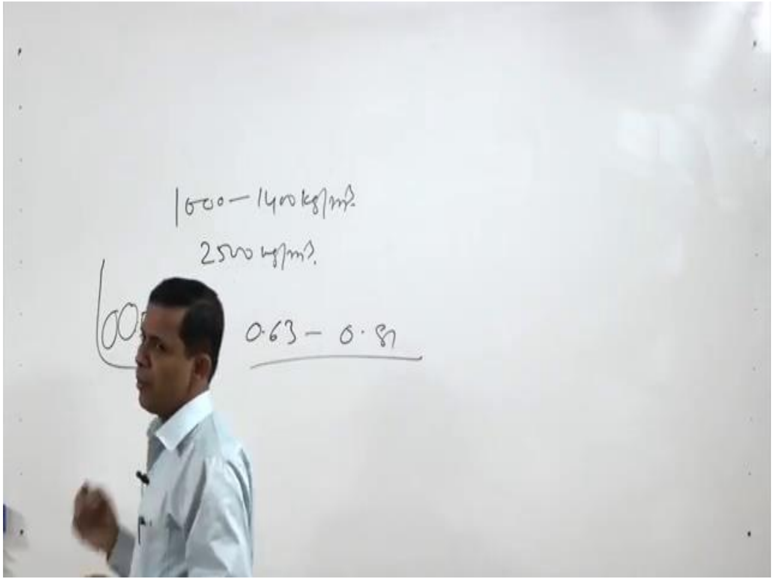

We can get 1000 to 1400 kg per meter cube density of the briquettes. We can get, but if it is a piston press even we can get up to 2500 kg per meter cube. So, normally that 1200 to 1400 gram per meter cube density it is achieved, but hydraulic piston press makes less dense briquettes sometimes below 1000 kg per meter cube. Here we will see some example. So, if have materials is rice husk and cassava peel gel, then volume before briquetting is 100.53 centimeter cube and density bulk density.

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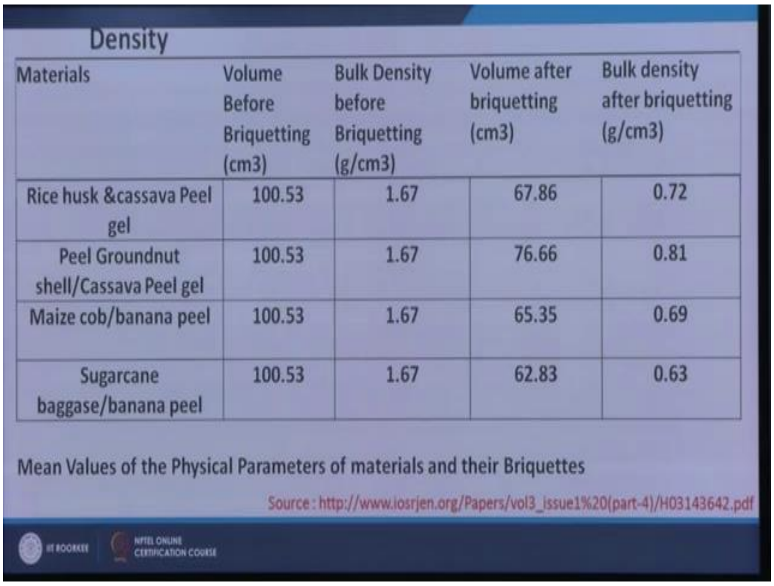

Density

Materials	Volume Before Briquetting (cm3)	Bulk Density before Briquetting (g/cm3)	Volume after briquetting (cm3)	Bulk density after briquetting (g/cm3)
Rice husk &cassava Peel gel	100.53	1.67	67.86	0.72
Peel Groundnut shell/Cassava Peel gel	100.53	1.67	76.66	0.81
Maize cob/banana peel	100.53	1.67	65.35	0.69
Sugarcane baggase/banana peel	100.53	1.67	62.83	0.63

Mean Values of the Physical Parameters of materials and their Briquettes

Source : http://www.iosrjen.org/Papers/vol3_issue1%20(part-4)/H03143642.pdf

Before briquetting is 1.67 gram per centimeter cube and here volume after briquetting is 67.86 centimeter cube and bulk density after briquetting is 0.72 gram per centimeter cube. So, we see here the volume is reduced due to the briquetting so; obviously, density will increase, but interestingly bulk density is reduced here. So, why; so this does not mean that density is increasing bulk density is reduced. This is because of the increase in the particle size. So, when we will store some material. So, that will the wide space inside it will depend upon the particle size. If the particle size is bigger the wide space will be more. So, that is why the bulk density has reduced here, but actually true density is not reduced.

Some example for other materials like peel groundnut shell and cassava peel is also given some other maize cob and banana peel sugarcane baggase and banana peel all information some informations are given. So, on the basis of this data it seems that the bulk density after briquetting is varying within 0.63 to 0.81. So, this is the normal range within which the bulk density varies now we will discuss on the friability. So, what is friability? So, that is the property of the resistance to mechanical shock. So, if some material is under mechanical shock, how it is resisted to it that it is related to the friability.

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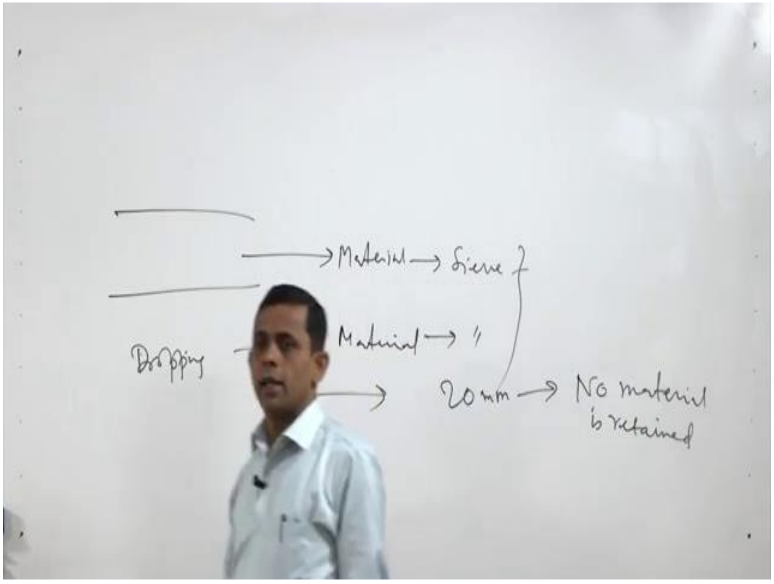

So, how can we measure the friability, for the measuring of the friability either we can use a rotating drum say rotating drum we put the material inside the drum and we will give some certain rpm and continue for certain period then we will collect the material here, and we will sieve it or we can drop from certain height for several times, then we will collect the material then that material either dropping that will also give the material. So, that is also sieved. So, any process we can used we have to get the final material and we have to sieve it. So, after sieving we will be using 20 millimeter sieve.

So, how much material is retained is used as the index of briquettes friability. So, if the briquettes friability is 0 this indicates that when we will be using the 20 millimeter sieves, no material is retained no material is retained; that means, that all are fragmented are broken down. So, that is not desirable. So, 0 friability index is not desirable. So, generally briquettes produce by mechanical piston press and screw press are hard enough to be transported by lorry for considerable distance without any degradation. Next we will discuss the resistance to humidity. If we store the briquettes for a longer time in humid atmosphere it loses it is strength it loses it is properties.

Why so? Because the briquettes we have seen can be produced either at high pressure or low pressures low pressures low pressures is binding agents high pressure even uses inherent or indigenous binding agents. So, those binding agents external or indigenous that are lignin are soluble in water.

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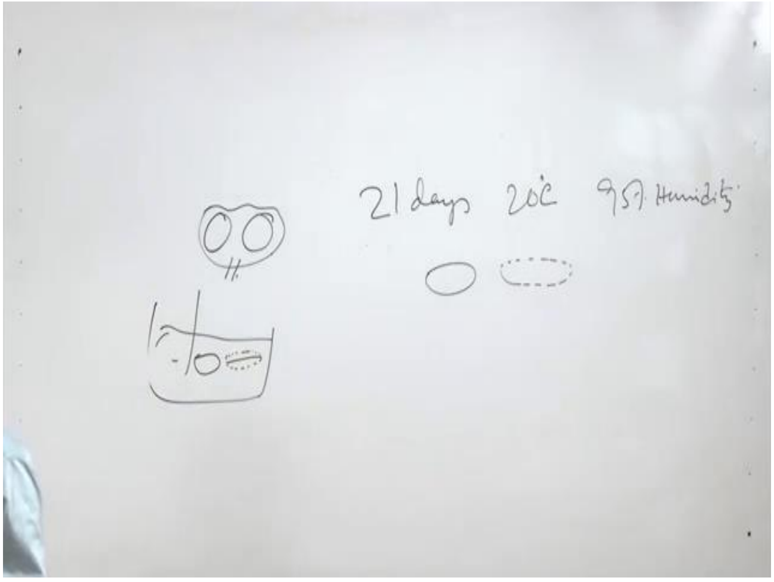

So, when the binding agents are soluble in water at that time the solid particles are not binded or not very close to each other, they are they are attachment is being weaken. So, that is why it loses the property. So, we have to quantify the humidity resistance to humidity; that means, we will be putting the material under humid condition and we will see how long it is able to resist it is position or how it is changing it is property by it is expansion.

So, that will be studied. So, for this case, it is traditionally tested in immersion test the briquettes are dunked in water and the elongation or swelling of the briquettes is recorded if we put water we dunk it in to this some briquettes then the briquettes after certain times say longitude.

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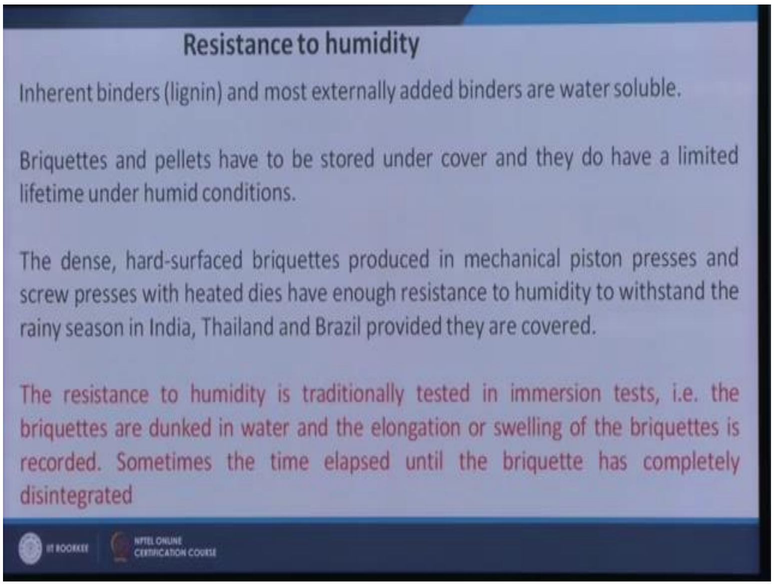

So, this way we can quantify the how much elongation taken place after how much time. So, we can quantify your resistance to humidity alternatively we can keep the briquettes in humid year for a prolong time for a longer time. So, that it is one specified is 21 days time at 20 degree centigrade at 95 percent humidity. Then we will see initially the briquette we had now how much elongation has taken place. So, how much elongation has taken place if it is thirty percent elongation then it is expectable, but if it is less than 2 percent that will be the ideal case.

So, this way we can quantify the resistance to humidity. Next we will see the heating value, we have discussed in our previous chapter in the characterization module that we have discussed how to get the heating value of solid materials. We used the bomb calorimeter. So, bomb calorimeter can be used experimentally to determine the heating value of any materials, but some empirical models are available which can be used to determine the heating value on the basis of it is proximate analysis or ultimate analysis we have discussed in detail for general biomass and waste.

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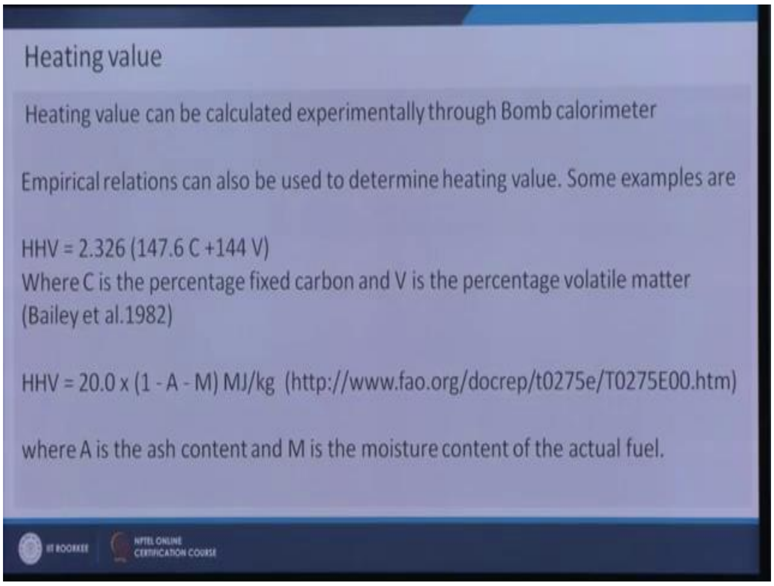

So, here also those can also be used for briquettes. Some examples are here at it is high heating value is equal to 2.326 into 147.6 C plus 144 V where C is the percentage fixed carbon and V is the volatile meter in percentage. And another is high heating value is equal to 20 into 1 minus a minus m mega joule per kg is taken from this source. And where a is the ash content and m is the moisture content of the actual fuel.

Now we will see the applications of these briquettes the briquettes can be applied in many cases, few are reported here the one is boilers the briquettes can be used in boiler to produce your flue gas that can be used for the production of electricity or heat.

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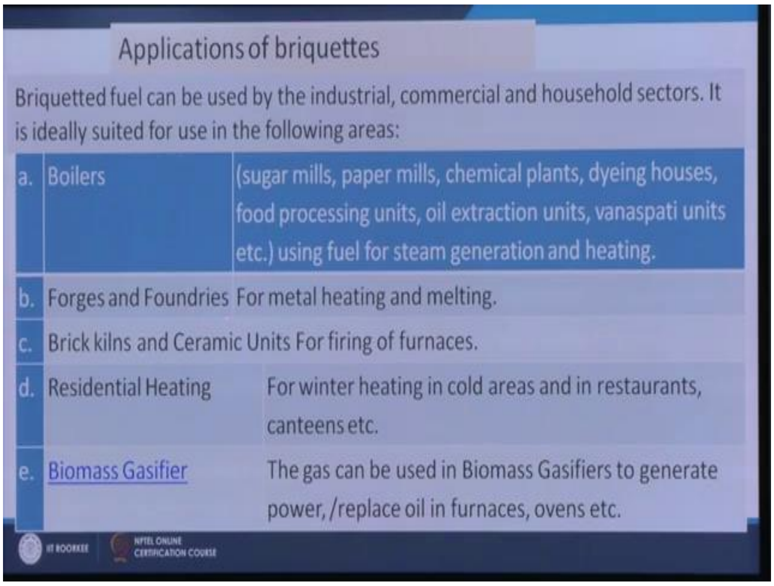

So, boilers in sugar mills paper mills chemical plants dyeing houses, food processing unit is oil extraction unit is Vanaspati unit is etcetera. And forges and foundries for metal heating and melting. The briquettes can be used briquettes can be used for brick kilns and ceramic unit is for firing of furnaces. This can be used for domestic applications for winter heating etcetera. This can also be used for Biomass Gasifiers; the gas can be used in Biomass Gasifiers to generate power.

So, these are the applications of briquettes. Now in residential heating how this can be used or in industrial applications what type of equipment can be used or furnace can be used for the use of this briquettes.

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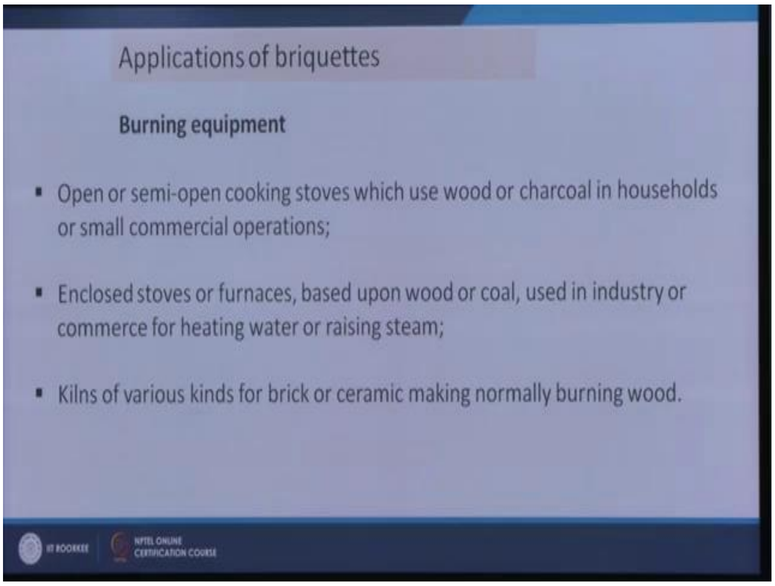

So, open or semi open cooking stoves open or semi open cooking stoves are used for domestic applications. And enclosed stoves or furnace based upon wood and coal that can be used in industry, and kilns of various kinds for brick or ceramic making normally burning wood. Now we will discuss on the manual briquette machine. So, we have discussed in the first part of this module on the machines used for high pressure briquetting, but for low pressure briquetting, we have not discussed any machines.

So, this is one example of that machine which uses low pressure with respect to those high pressure machines and gives us the briquettes. So, this manual briquette machine I shown in this slide we see here this has different parts.

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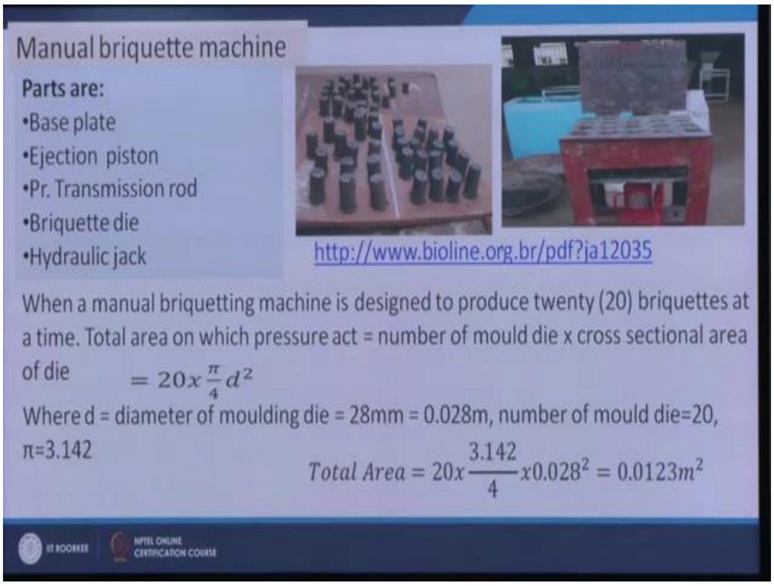

So, one had base plate. So, this is your base plate. So, one is ejection piston, another is pressure transmission rod. Then is briquette die and another is hydraulic jack. So, this is a hydraulic jack at the bottom of this. So, this hydraulic jacks give some thrust upward and that force which is applied upward directions that are transmitted to this transmission rods. And transmission rods are having some ejection piston and these are the die which is called your pellet us or briquette die. So, material solid material put inside die then this coverage closed then from the bottom the pressure increases, the hydraulic jack increases the pressures, though it is moves upward and the compaction compression concretions and concentration takes place here inside this as a result we get the briquetted forms.

So, we do not use our very high pressure. So, just we give the shape and then after opening this it is ejected from this die and it is given some time for curing. Now we will see how much energy will be consumed to generate certain number of dies or certain number of briquettes at a time. So, one example says if a manual briquetting machines has 20 say briquettes die.

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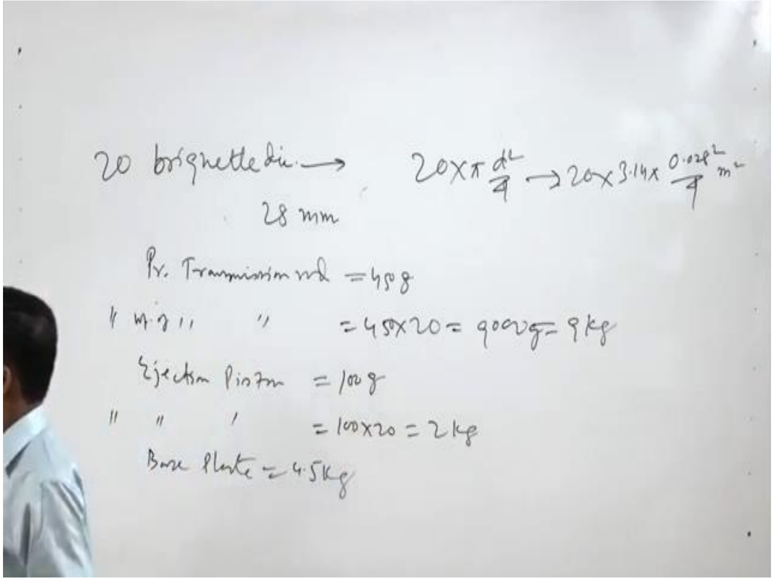

If as say 20 briquette die, then how much force it will be requiring how much weight. It will be lifting at a time. So, 20 briquette die we are having. So, if one briquette die is having say 28, 28 millimeter of diameter if it is having 28 millimeter of diameter. So, what will be the area through which the pressure will be transmitted? That will be 20 into pi d square by 4 that is 20 into 3.14 into 0.028 square by 4.

That is meter square that is meter square. So, this much area we are getting through which the pressure will be transmitted. And now let us say what will be the weight that can be lifted that has to be lifted by this hydraulic jack, for this to calculate this we need to get the weight of base plate ejection piston each ejection piston each pressure transition rod and briquette die we have got here, the how much material is put inside it and this things we need to know at first. So, here it is given; so mass of one pressure transmission rod. So, pressure transmission rod mass is equal to 450 gram. Then it has how many numbers as 20 dies are present.

So, 20 pressure transmission rods will be required. So, total weight of weight of pressure transmission rods is equal to 450 into 20 that is equal to 9000 gram that is equal to 9 kg. Now ejection pistons, mass of ejection piston is mass of ejection piston is given here that is 11 that is 100 gram for each. So, total ejection pistons mass will be 100 into 20. So, that is equal to 2 kg that is equal to 2 kg. Mass of base plate is given 4.5 kg, mass of base plate equal to 4.5 kg. Now in each briquette die 50 gram materials we can put. So, mass of that is mass inside briquette dies is equal to 20 into 50. That is equal to 1 kg that is equal to 1 kg. So, how much weight the hydraulic jack need to lift.

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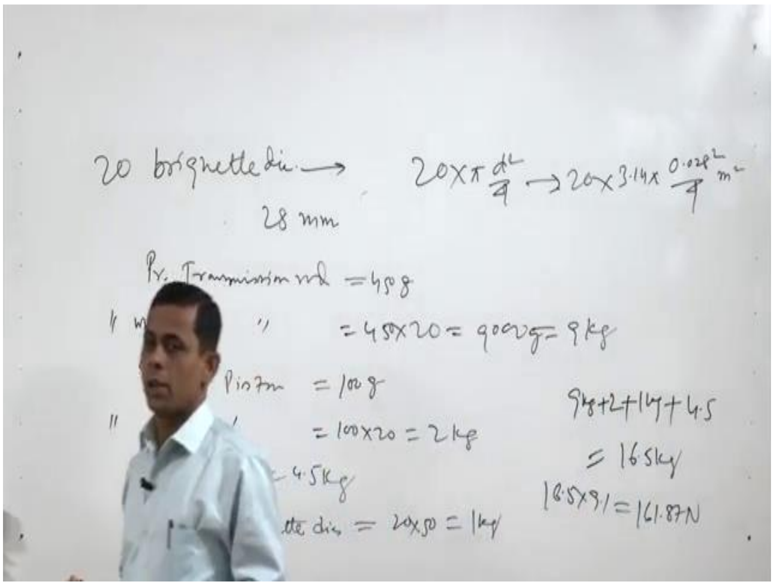

Now, we can calculate that is equal to the transmission rods that is 9 kg, plus your ejection piston 2 kg plus briquettes that is 1 kg plus the base plate that is 4.5 k g. So, we are getting here the total is equal to 16.5 k g. So, 16.5 kg we are getting if g value is 9.8 one then weight to be lifted in Newton unit that will be 16.5 into 16.5 into 9.1 that is equal to 161.87 Newton. So, this much of weight has to be lifted by the machine.

Now, let us see how much force will work, here say a 10 tons, a 10 tons hydraulic jack was used to lift the machine components and compress the briquettes. The compaction force can be calculated using the pressure.

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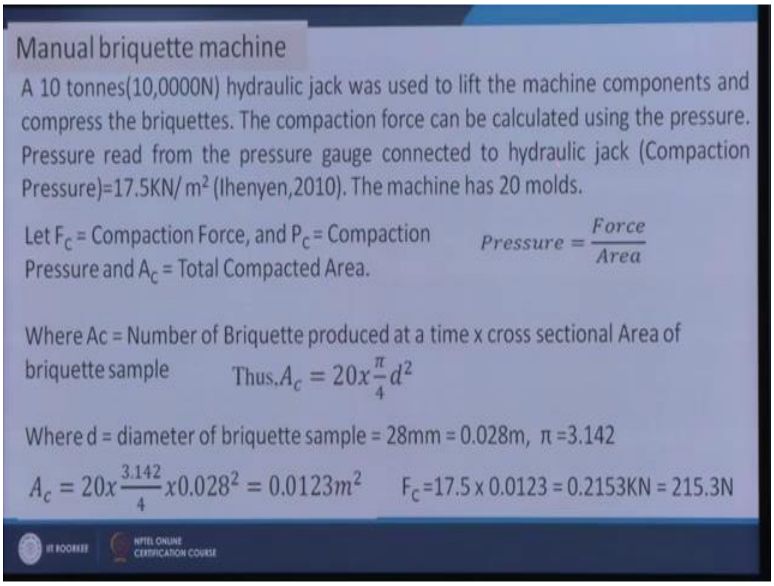

So, pressure read from the pressure gauge connected to hydraulic jack is 17.5 kilo Newton bar meter square the machine has 20 molds. So, how much pressure force is exerted on this machine that has to be calculated. So, force is equal to when a pressure is equal to force by area. So, force F c compaction force is equal to pressure into area for compaction.

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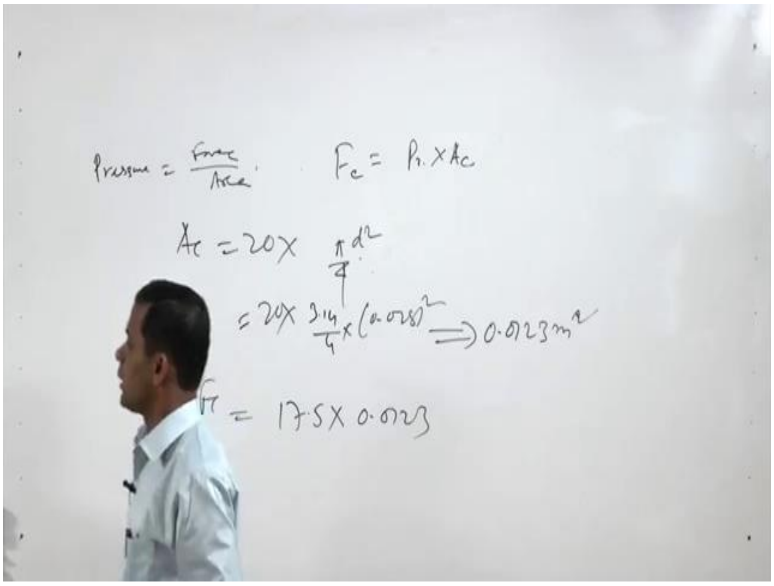

So, compaction area means the area of the dies. So, A c is equal to 20 into 4 pi d square sorry that is equal to pi by 4 d square that this value we have calculated, that is equal to 20 into we are getting 3.14 by 4 into 0.028 square. So, this value is equal to 0.0123 meter square. So, this is the A c and pressure. We are getting 17.5 kilo Newton per meter square. So, what is F c, F c is equal to 17.5 kilo Newton per meter square into 0.0123. So, that is equal to total 0.02153 kilo Newton 0.2153 kilo Newton or 215.3 Newton. So, this way we can calculate the energy requirement for lifting the material for the production of one set of briquettes.

So, up to this in this module we have discussed about the fundamentals of densification different types of densification processes, the reactors used for it. And finally, we have given some example of manual briquette machines and how to compute the energy requirement.

Thank you very much for your patience.