**Mining Machinery**
**Prof. Khanindra Pathak**
**Department of Mining Engineering**
**Indian Institute of Technology, Kharagpur**

**Module - 07**
**Lecture - 39**
**Air Compressor**

In our last class we discussed about this turbo machinery, we have talked about this different type of pumps which are used in mines. Today I will introduce you some other turbo machinery that is a Air Compressor. You may be knowing that is a compressed air has got this capacity of doing work.

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Because, it has got the power and then how air does work and that what is the power of compressed or at a high velocity air that you might have seen, how during the storm that

windbreaks houses, wind breaks this trees, so that means, that power it is there with the high pressure or that high velocity wind.

Now, that how we can use it for industrial purpose for that we will have to have some machine by which you can control this air. So, you will have to first that is a mechanical energy, will have to be converted to air pressure. So, that why this say compressor this is a machine which is exactly we say it is a pneumatic device, compressor air compressor is a pneumatic device.

And the purpose of it is to convert power that is we can use the power originally from either diesel power or electrical electric motor or diesel engine, that you use for getting the main mechanical energy or the mechanical that from that power we get into as a potential energy, it will be stored within that air in a compressed air and that air can be released through some valve and then you can control it to do some useful work.

So, this is what exactly a compressor, we need to know about these machines. In the photographs here you have seen say this type of compressors are there where you can have a even a this is your trolley mounted one, which will be just we can touch to a vehicle and it will be going to the place of your applications. You might have seen some this type of compressors in some of your water well drilling in the villages.

Sometimes the drilling machines they bring it over there and if you have visited mines, you might have seen that compressors work a lot of things. Earlier, there is and I told you about this a in a mine transport also, the locomotives were underground locomotives were used that is a by compressed air operated.

There are drilling machines say for example, during the 80s 90s one of the most common type of drilling machine which were used in Indian surface mining was the Russian design manufactured by heavy this ones are heavy machinery company that is our h is heavy engineering corporation at Ranchi. They were having you see any old mining persons in India

they will be telling about that SBSH, that is 250 millimeter drill which were whole thing were pneumatically operated.

Other than that many of our Ingersoll Rand Atlas Copco they have got this drilling machines which are powered by this compressed air because of certain advantages it has. So, we will be today talking about this compressor.

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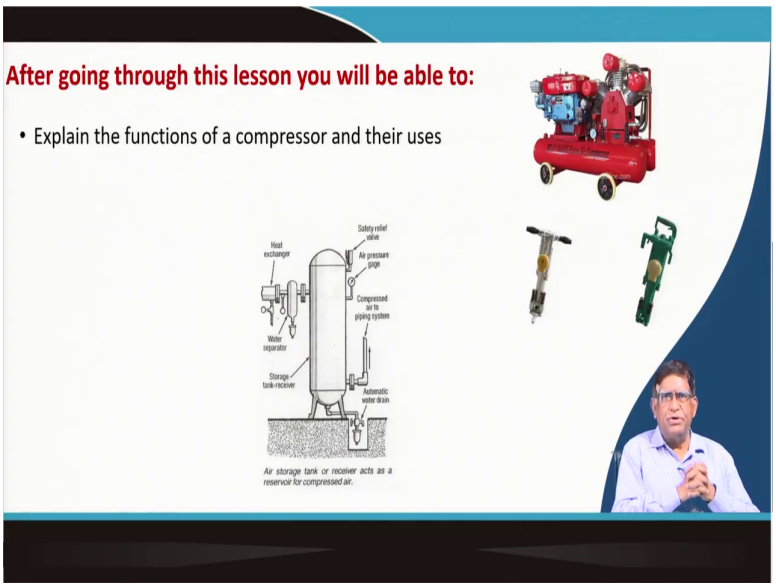


So, that you after this you should be able to explain that what a compressor is. The compressors as you can see here, it says simple trolley mounted or it can have a depending on the purpose where you use. You have send us compressor is a multipurpose used machines, you will get it in the food industry, you will get it in the this our many other manufacturing industry, many places say you have got the compressors you might have seen for inflating your tires for that purpose also,

They use a compressor keep the air in a compressed form. So, that whenever you need to inflate your car or trucks tire you go to a that. So, the depending on that you can have a different type of installations depending on what pressure you need, how much volume you need switch on that. So, as the basic you can see that what is there in a compressor installations, you will be having a vessel where you will be as a storage tank which can be a vertical one, which can be horizontal one.

Here you can see a horizontal one over here and then there will be that an intake for the air will be coming and there will be that for releasing that, that is your the upper, it will be used there can be that if the water and all will be coming over there that can be drain off from the compressors.

So, this as a heat exchanger unit could be there and then sometimes they separate the water also. So, the dry air gets stored over here. So, this depending on the installations you will have to know what is the main pressure level, depending on that you will be having. So, a control system, a regulation system, that is your compressing system those are the main systems which is there in a compressor unit.

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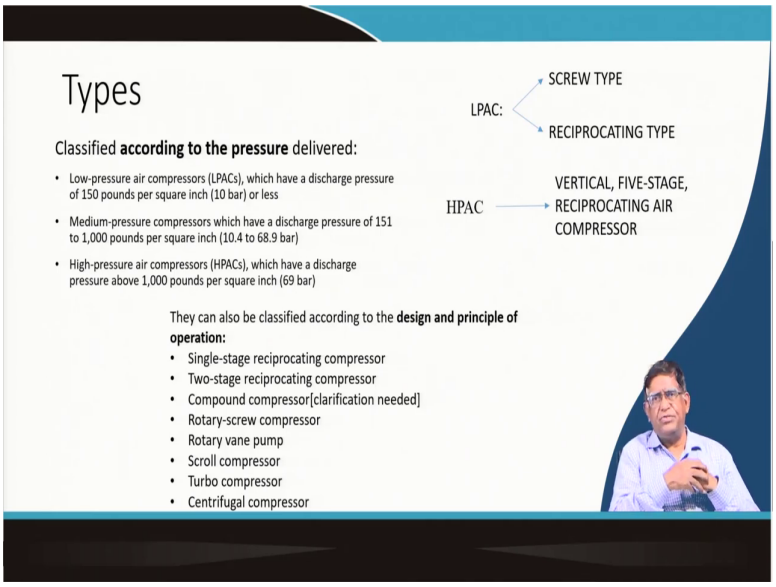


So, this compressors, we need to know that there are different types of compressors are there; depending on what is there exactly your low pressure air compressors, which the pressure range will be within 10 bar that is a low pressure. Sometimes it can go up to say 70 bar 60 that is 10 to 70 bar that is your up to 1000 PSI that is around 68.9 bar, that is a medium range of air compressors, then there are also some higher size air compressors where this is pressures they can generate much more.

Now, this is a low pressure air compressors we get two types of them- that is a screw type and reciprocating type. We will discuss about what is this screw type and reciprocating type, but you can see that this your high pressure one, they are exactly can be number of stages. As in the pump you have heard of this single stage, multi stage that is your a high pressure air compressors that they are also coming in a multiple stage.

So, that means initially they will be rising to one and then again second stage, third stage, it can go to multistage air compressors. Now, other than this there could be a different type of this air compressors which could be a compound compressors, there could be rotary screw compressors, later could be rotary vane compressor, scroll compressor, turbo compressor, centrifugal compressor.

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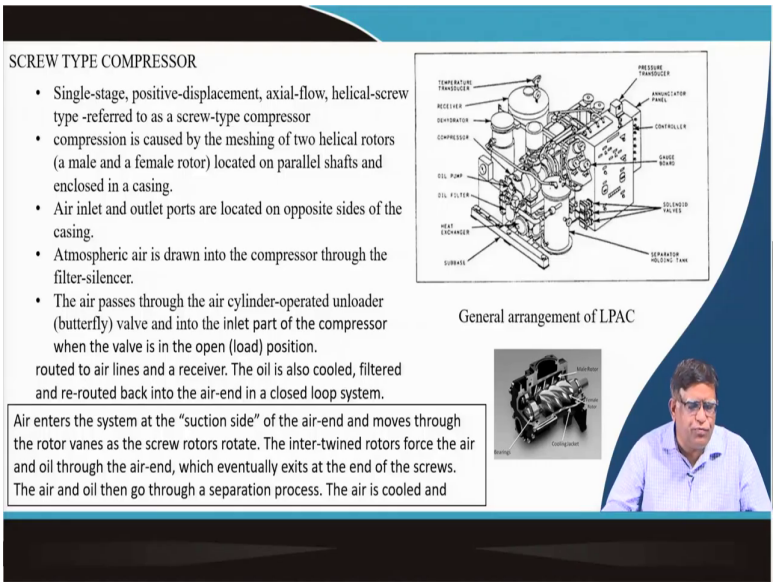


So, that means depending on how you use these compressors can be different. So, if you talk of a screw type compressors, here in this diagram you can see a there are two screws- one is exactly called male rotor and there is a female that is your rotor.

These two get engaged and by that they will be supported on the bearings within that they will be given the rotary motions over here and then they will be as a positive displacement of the

air will be getting slowly energy will be converted to and then it will be compressed and kept into a pen.

So, that is a in a single stage positive displacement axial flow helical screw type, this is as a screw type compressors you can see that how helical screw goes. And now if you see a installations that is where a compressors will be there, there are number of accessories are there, different moving parts they need to be lubricated for therefore, there will be a lubrications for that oil will have to be there, then there will be because when the air will be compressed at a time it get air get heated up.

So, that is why there must be a cooling system, then there will be a heat exchanger for that and then there must be exactly you will have to control the your the compressed air, how it will be going to do the different operations for that pressures need to be controlled, that if your speed sometimes need to control depending on the type of use.

So, there will be a controller then you must have the sum measuring system, the different type of pressure gauges will be there. So, then the air which is coming in if there is a moistures and all if you can remove it, it is good that is your to make a dehydrated, so that dry air can be compressed. So, for that you will have to have a properly monitoring the main thing you monitor three things that is the temperature, pressures and the humidity. These three things are monitored and accordingly you control these things.

So, they say compression how it is caused over here in this between the screws that is your, it is by that helical rotors when they will be in if they are in a parallel shaft. So, when they are just rotating both matching one will be rotating in the opposite directions, the air trapped into it will be pushed towards the that is your to the from one in take end one outlet end.

So, the air will be getting puss just like your screw conveyor in a or you can see in an auger the material in a helical paths the material is coming up when on a wood, you want to make a auger what it happens? Exactly the material which is cut by the point of it, it is in that groups it comes out and it moves.

So, basically that screw or a auger is a conveyer, by conveying the material up there. So, here exactly that is the air which is coming in they get pushed through this the helical matching pair, the air is moved forward. So, that is why it is called a positively displacing it. Now this is a air inlet and outlet ports are they are placed in the opposite directions and whole thing is in a casing. So, that there is in air tightness is maintained over there.

So, when the air is entering into it at there it is at an atmospheric pressure and then there is always say when there will be a aerodynamic noise. So, to see that that is exactly this compressors wherever you go there you will find there will be lot of this noisy piece of equipment. If you see any drilling machines operated powered by this compressor other than the your the other vibrational and other rock cutting noise, there will be the more noise because of this aerodynamic noise that released by the compressor.

So, that is why that wherever possible during the at intake axis at there would be a silencer, so that this noise can be kept certain amount reduced. Now, this is a when they are ultimately it will be going there there will be through a valve they will be released. So, that wherever to be used valve is nothing but it is a gate, you are just opening or closing so, that the compressed air can move out.

So, now what is you can say just like in a pump we have also here a suction side and then once as your discharge side ok.

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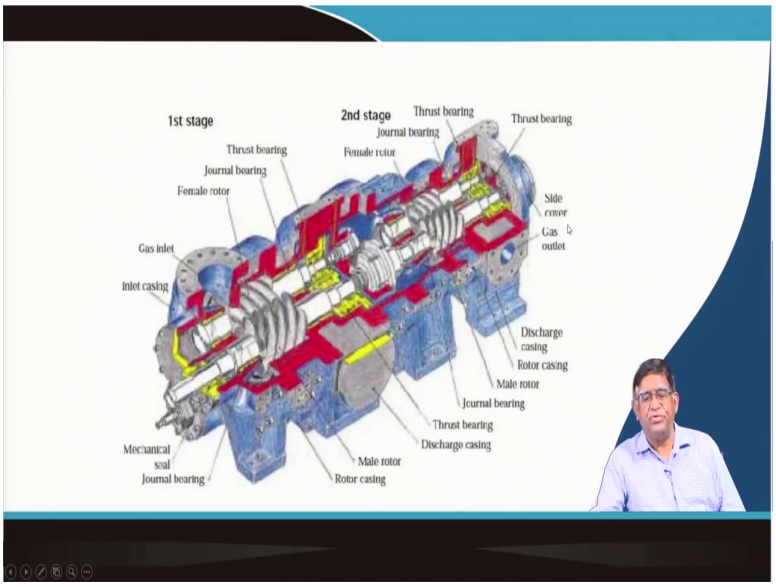


So, this is a there must be a cooling system and then there must be because that cooling system sometimes with the oil also. You can see in this figure, there is a how there are 2 stage- this is a 1st stage and there is a 2nd stage; that means, whatever will be pressurized, that pressurized air is getting further pressurized and it will be there.

So, that in a when we study the mechanical engineering of it, you will find that there is a journal bearing and a thrust bearing, you have studied and your preliminary about the machine elements that what the bearings roles are exactly there where you use you are using a journal bearing here, but there will be a thrust bearing by which exactly it is taking the load as well as they can smoothly rotate there will not be any wear and tear at this point at the support point of the shafts.

Now, this is a as you can see here there will be a casing, you can see this big metal casings it is cut view very nicely given, you can see that the end referentials are given then there is a mechanical seal that is. So, that dusts and moistures other than they should not get entered into it. If some foreign material comes other than they say if a dust particle they will be damaging that metal parts of it and also the compressed air when it will be released there could be problem with the your appliances.

So, that is why there should be a proper seal over here, then there will be this you have got the same type of operations both the unit only thing is that your in a 2 stage you have got little bit higher pressure rating over there.

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So, if you see a single stage that how within a casing, how the screws are put over there and then from their how from the intake air will be going out that you can see here there is a air

filter at the top, you can see the air is sucked through this filter. So, that it is coming over here and it is going out at this end. So, by that the all the dust particles and others are removed or kept away from the compressor.

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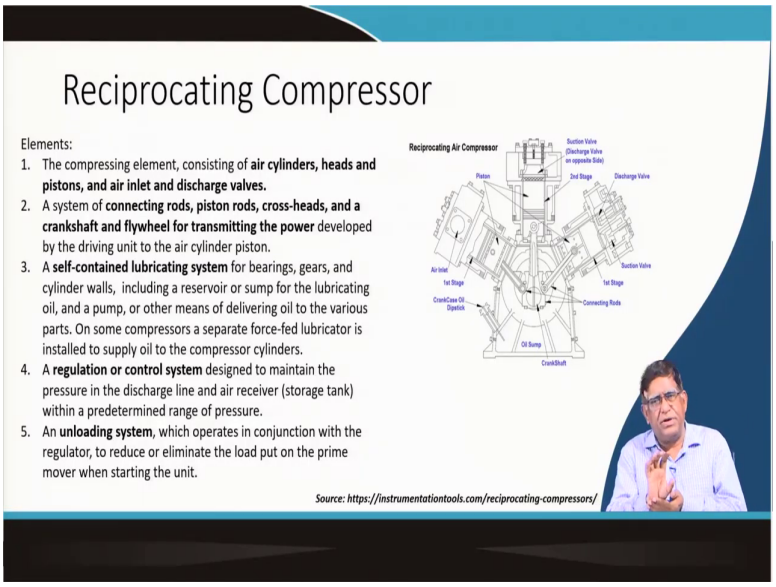


So, you have seen that a screw type compressor, it is a rotary type of compressors, but the most common type of reciprocating compressors is shown over here there are different elements. You can see here there are three pistons are there that is your here when this is rotating as a come then this your pistons there are three pistons of these three compressors at their coming out and there are they are working just like your in an IC engine you have said that the force strokes,

They when they this is coming downward when this will be rotating this one this piston will be coming down then this will be sucking. At the top there are two valves, now that the

suction valve will get open when you are moving it down and then when it is going down at the same time one pistons will be going upward, then when it will be going upward the air which is drawn that will get compressed. So, there is a one bottom dead center and one top dead center within that this piston is moving.

Now, when this is going upward there will be a pressure given, under that pressure there will be a discharge valve will be opening. So, in a reciprocating compressors depending on we are having here three cylinders, there could be a small compressor with only one cylinder or there could be multiple cylinders that depending on how much volume you want to get compressed within a particular time, depending on that you will be designing the compressors.

Now, basic thing is very simple, we will be having a prime mover by which your this crankshaft will be rotated and your this three piston on a crankshaft will be moving in such a way that there will be this a air will get compressed periodically and get inside that your air vessel or cylinder. So, is this written here we can go through it the decompressing element consists of the air cylinder heads and pistons air inlet and discharge valve.

So, basic compressing operations is done by this three as I described you that in this inside the cylinder, we have got the cylinder head and there is the piston. The piston moves then the air inlet that is a valve get opened up and then when it is moving the other side, it get compressed and then the your the air will be compressed air will be delivered to the your the main container where it will be stored.

So, that is that system will be having a connecting rod, piston rod, cross heads and the crankshaft and flywheel and transmitting power. So, this is arrangements just like an IC engines you have studied then this self contained lubricating system, because these pistons and all will be moving.

So, just like in IC engine you have got an lubrication system, here also you will have to have a lubricating with can be you can have this oil sump when it is rotating at that time the oil is getting sprinkled over here or there could be a forced lubrication or this splashed lubrications

by which that pistons will be lubricated. So, that heating will not take place, then there will be the pressures at the discharge point it will have to be regulated.

So, you will be having a valve by this is opening how much you want to open depending on that, so you will be having the your flow meter pressure flow meter and then this a you can measure that at what velocity at what pressure the air is going out. So, that is where you are having a control system and then there is a regulator. So, that you can do that when you are going to going on this compressing air after some time that what depending on the capacity of the cylinder, your automatically that your prime mover will be switch off.

So, that you cannot go on further, giving it over there. Similarly, in a continuous mode of operations you can keep that if the compressor level goes down, then it can automatically the power switch may be put on and the air starts compressing. So, there are lot of literatures available other than your text books of any textbook of turbo machinery will be explaining about that that.

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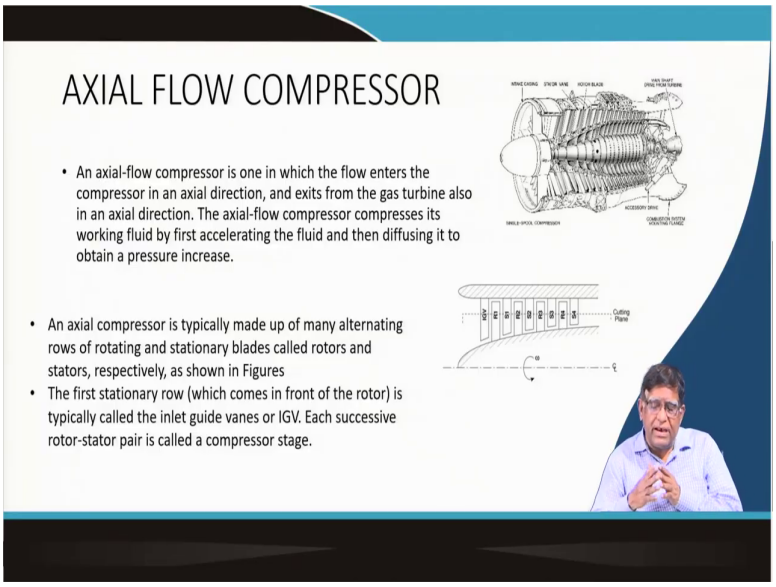


Other book which I referred to you as a pump fan and compressor that books gives the detail of it of the theory. The other that is your reciprocating and then screw type your centrifugal type you have seen there is another type of compressor switch is called axial flow compressor. In an axial flow means the flow is inner the in a parallel to that shafts.

So, here in that axial flow compressor in which the flow enters to the compressor in an axial direction, an exit from the gas turbine also in an axial direction. So, it is just coming in like this and then going out that is what exactly in a that is along this part. In other cases you have seen it is radially coming in and that in other compressor they have got a in inlet it is coming over there rotating and then going out and axial that is it can axially go out, but here it is coming in and out already.

So, this is where the shaft is rotated that on which you have got some stator and rotor fixed. So, this is just like a turbine, now you can see here there is a we are having this intake casing in that casing we have got some stator vane, you can see here this s 2 that s 1 s 2 these are the stator vanes and there are some rotor vanes which are connected with this your main drum, on this they are having this rotor vanes connected over here.

And then this your these whole thing, this main drum rotor it is connected with your main drive systems with a motor. So, then you can have the different or for the drive accessories breaks bracing is kept over here, their control is connected to this.

So, now sometimes this can be directly connected to your IC engines and the depending on the when prime mover you use it over here. So, if this is something like a your multi stage compressions do take place over here, your how this you are having the inlet guide vanes, this is that your inlet guide vanes and then successive rotor and stator it is getting successively compressed over here.

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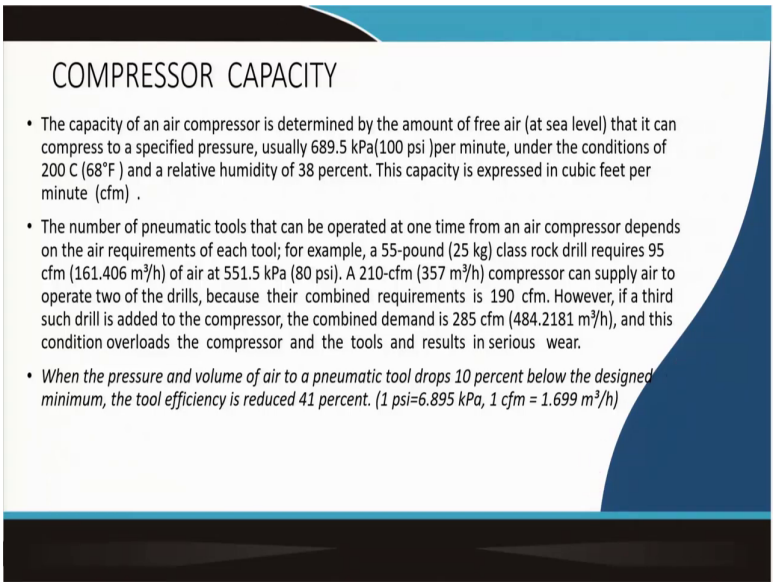


So, now you have basically learnt type wise, you have got number of different types the primarily you are reciprocating types, that your rotary type, that is particularly the screw compressors and also axial flow compressor these are the used in our industry. Now, one most important thing to know about that what is the capacity of the compressor. The capacity of the compressors is exactly that how much free air that can be compressed and then to a specified pressure.

That is a capacity a compressors that the free air is whatever is outside from there it will have to take and then up to what pressure it can reached. Say, as it is said that it can be your that is your 100 psi pressure you are per minute you are getting it over here; that means, you are about 690 kilo Pascal's of pressures per minute you are generating, that is the capacity that

you are keeping it over here . So, now there is a the depending on the that your air requirements of the different tool.

Suppose, you are having a air compressors, you are running one drilling machines, then you want to use also there want to give it to a blower, you want to give it for some let say cleaning a surface, you want to that give a pressurized air over there. So, like that the from one same compressor also you want to inflate something say. So, different jobs can be done by the compressor. Now, when you want to connect this different units, you must see that what is the capacity of the compressors.

Now, if the capacity of the compressors that depends on exactly sometimes they give that how much kg it as said it they say sometimes a 55 tonne compressor that is a small compressors, you may have a that is your 80 that is a your depending on the pressure rating can be more then what happens? When you connect two different devices, each devices has got its again a capacity it requires this much air per minute.

Now, if the sum total of the total air required per minute of these two devices are more, then your that that compressors will not be deliver that pressures. So; that means, this you remember here at the time you are compressing and using it is not like that of your in what you see in a garage that when you go for your the this a car the inflammation purposes, there we are having a statically that pressure one which is made and store is there then you are using it over there.

But, when you are doing a drilling machines, your per minute it is compressing that much and that is being consumed. So, that system should be clear in your mind. So, this is exactly the pressure and volume if they drop than the required, then what will happen? The efficiency of your using machines will be going down.

So, for example, you are drilling a machine in a drilling machines when you are doing a compressed air, exactly you are giving a drilling rod a rotations and also you are giving a pressure by say a pneumatically you are giving a pressure say axial thrust on the drilling rod.

Now, for that to give that to run that one pneumatic motor require pressure that is air compressed air at a particular capacity or particular pressure.

Similarly, your when you are giving this axial thrust on the drill rod, you are running a if it could be a system with a chain systems, you are giving that axial thrust which is pneumatically powered, now that also requires as a particular that is your pressure. If your compressor is not capable of giving that much capacity is less, then if the 10 percent below capacity can lead to your efficiency reduction by 41 percent.

Now, that should be clear in your mind that whenever you are using a pneumatic system be careful about its capacity and then see that your compatibility of the size, that compatibility of the compressor size and the your applying size that is size in that in the name of that what is that their air capacity required an air that should be matched. If you do not match that then you will find that you are going to get a low performance.

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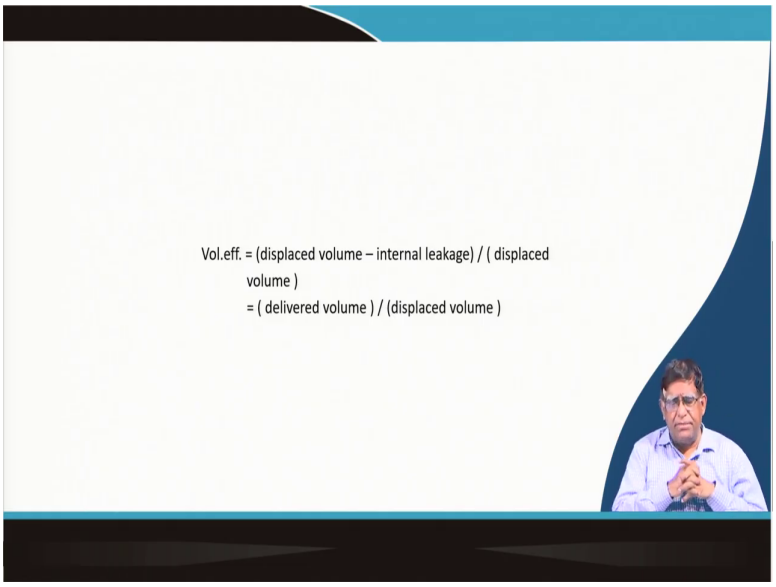


Now, the volume efficiency of a compressor is determined by what is the displaced volume and what is the internal leakage and then divide by the displaced volume. So, that is what exactly your delivered volume by the displaced volume, that gives the volumetric efficiency. So, you can easily find out from the rating and then you can find out while we are operating, if there is a volumetric efficiency is reducing, that you need to take proper actions that how you can improve it.

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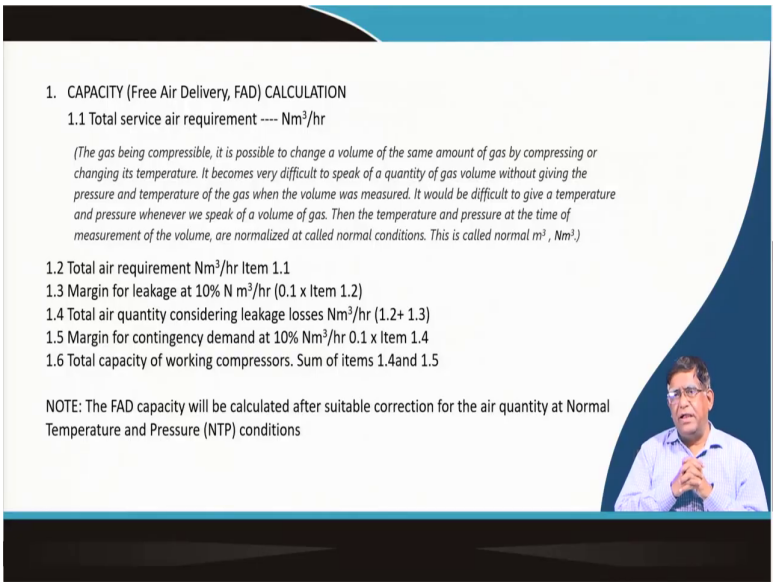


Now, this is a free air delivery that is a capacity which is always measures in normalize meter cube per hour. Now, what is that normalize things comes, you know that your mainly the universal gas equations and all you know that is it is a compressible air, that is a PBT by n is a constant that your the temperature, volume their relationship is a very very important.

So, normally that whenever you are using a air compressor you will have to normalize the volume, that is which could be at depending on the norm it is that at temperature whether you are taking at a 15 degree, 20 degree centigrade the temperatures and maybe with a what type of what is above at parametric pressures you are having that much volume.

So, depending on that applications and what the compressor manufactures are suggested you will have to take that normalized air. Now, to determine the free air delivery take the normalized air by what is a total air requirement. For the appliances is known to you and that

is whatever is this total volume as a normalized volume, then you keep some margin for the leakage. Normally, 10 percent margin is kept so, that is why 0.1 of this normalized volume that must there.

And then there is a this that their sum will be giving you the total air quantity required and then the you will have to have some margin as a contingency. Keeping all these things, so that means, while you are determining the free air delivery do not go by what is the exact capacity of the machines.

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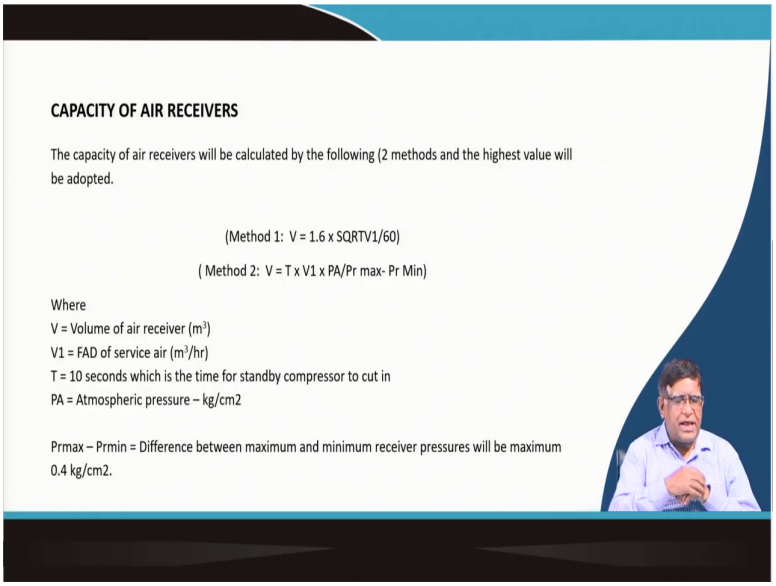


So, you take some additional things. So, that you can you are not deprived of the or that is your efficiency of the your appliance do not go down. Now, that say when you have to find out the capacity of the air receiver that what for a given appliances, what should be the size of the air receiver that is determined by exactly the volume of the air receiver, depending on the

free air delivery required for your appliances, that free air delivery if you take a square root of that divided by 60 this gives a one method.

And the other method is you take of the atmospheric pressures and the differences of the pressures, that is your if you take the difference between the maximum and minimum pressure which can be find out as a 0.4 kg per centimeter square, depending on that you can determine the capacity of the receiver.

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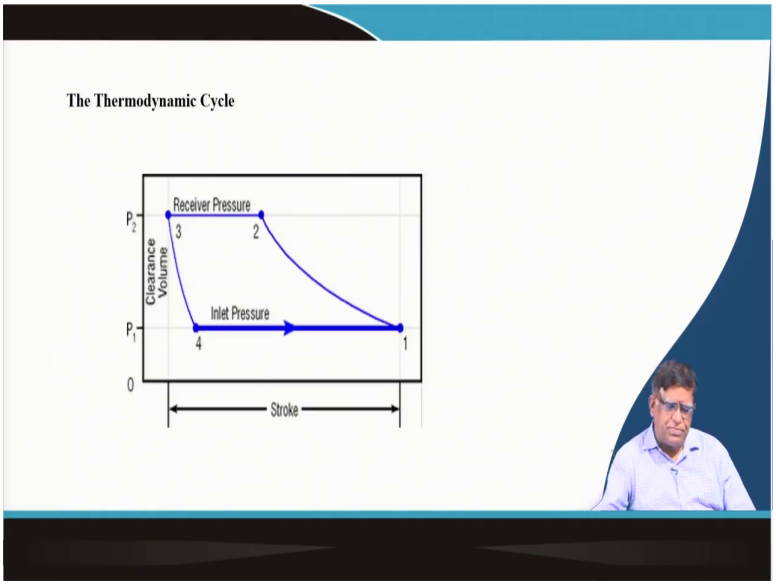


One basic things of the thermodynamic cycle should be clear to you, as I was telling in the reciprocating compressors in the three pistons, then when you are just bringing the piston down at a lower point at that time this much volume is sucked. So, this is a volume and this is your pressure, the pressure volume diagram, it gives that exactly how the thermodynamic behavior of the compressors.

Now, when you are starting that piston is going up or getting compressed during that time the volume is reduced up to here. When it is volume is coming up to here that pressures this volume that pressure has been reduced, the volume has been reduced pressure is increased at that pressure constant pressure the volume will be going into the your air capacity receiver.

During that time, this your pressure and the constant pressure delivery is there and then again when this there will be a clearance volume from the bottom top that center there is certain volume is kept as a clearance volume, after that the piston again start going down at the time some volume it get again expanded this much volume is expanding that clearance volume get expanded within that and then it goes again taking the sucking of air.

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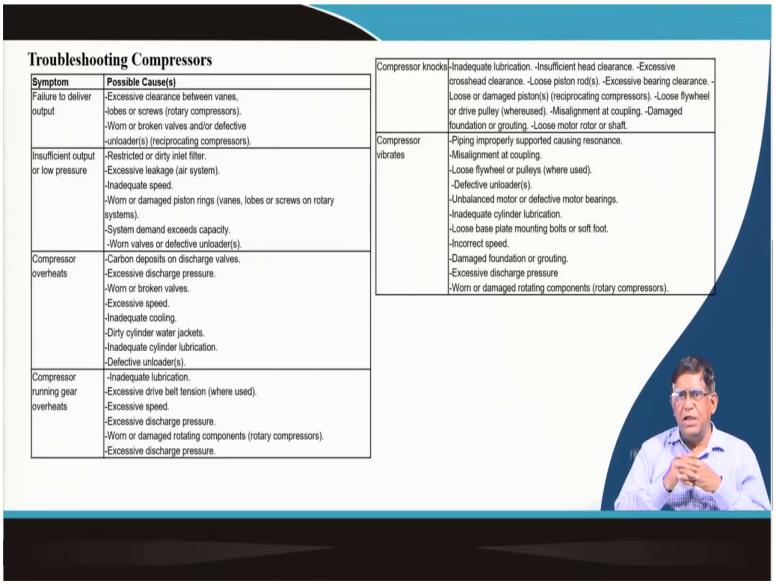


So, this is how exactly in a reciprocating compressors the things work. So, one more important thing you need to know about how do you do the trouble shooting of the

compressors. Now, this is a when you are working in the mines for a different purposes, there could be that you are not getting the delivery, that is your how much amount of output your free air delivery is reduced.

It can be there could be a more excessive clearance between the vanes or there could be your that rotary compressors are that the two screws are either the teethes have got worn off their gap has increased. So, you are not being able to deliver then there will be worn or broken valves. Sometime the valves are broken, so that is why there will be a leakage. So, you will not get that required amount of fuel.

Similarly, there could be insufficient output or low pressure which can be exactly there is a the air filter is not working properly, inadequate speed, that is your damage piston rings, then your there is a capacity the system is using more power, because of some that appliances also sometimes may be faulty because of it is taking more air and that much air exactly the compressors cannot give. So, that type of problems also may come.

Similarly, that there could be a problem of overheating; that means, your heat sink is not properly working, your cooling system is not properly working or there is a that speed at which it should run it is running at a very high speed. So, that at that time also there will be a overheating type of things. Then there is a the that even the that to drive the compare compressors, you have got a motor and the gearbox that gearbox is also getting overheated because of there could be that way you are doing a power transmission there if that is faulty, there could be the gear systems will be getting overheated.

Then there could be a problem of this compressor will be giving a knocking, that is the vibration sounds because there could be the lubrication problem may give over here or that if there is a lose some item somewhere it is lose or it is giving then also it will give a knocking sound.

Similarly, the compressor air it may vibrate that vibrations may because of the different unit which is connected over there, they are not properly balanced if there is a not the shaft alignment is not proper, depending on many reasons it may give a vibration.

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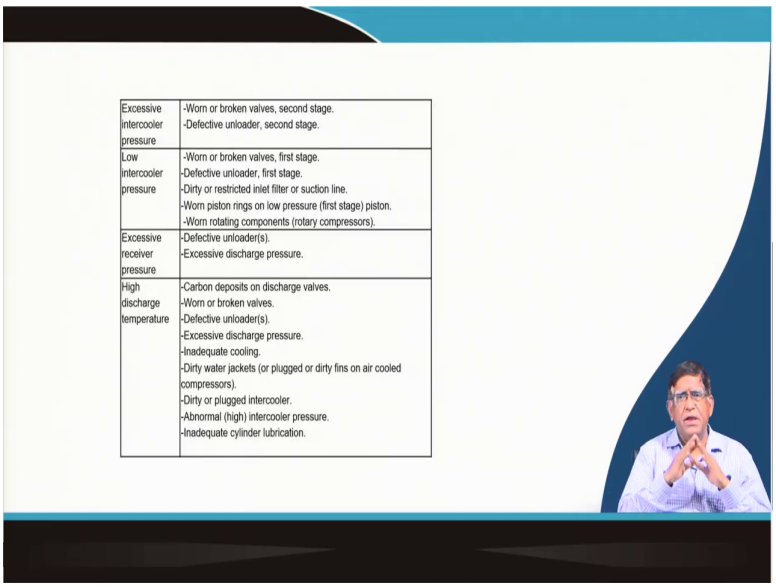


Similarly, excessive intercooler pressure is coming up. So, low intercooler pressure if it is anything deviation from the normal is a problem. Similarly, the your receiver pressure is coming high; that means, there will be some defect in some item. So, you will have to see the manufacturer's bulletin, that brochure and from that you make the checklist for preventive maintenance and then you do a periodic checking and maintenance over here.

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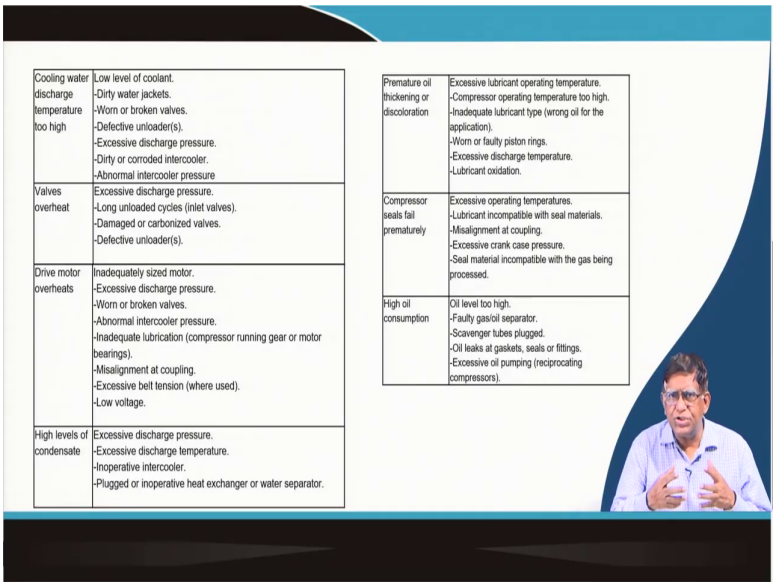


So, there could be a number of problems which are making based on the problems you will have to make a troubleshooting chart and that troubleshooting chart will give you a trouble free operations. Now, these machines can be brought under that is a condition monitoring. Sometimes if you do not do a condition monitoring then you will have to do a checklist monitoring by which your more time or the outage of the machines will be more.

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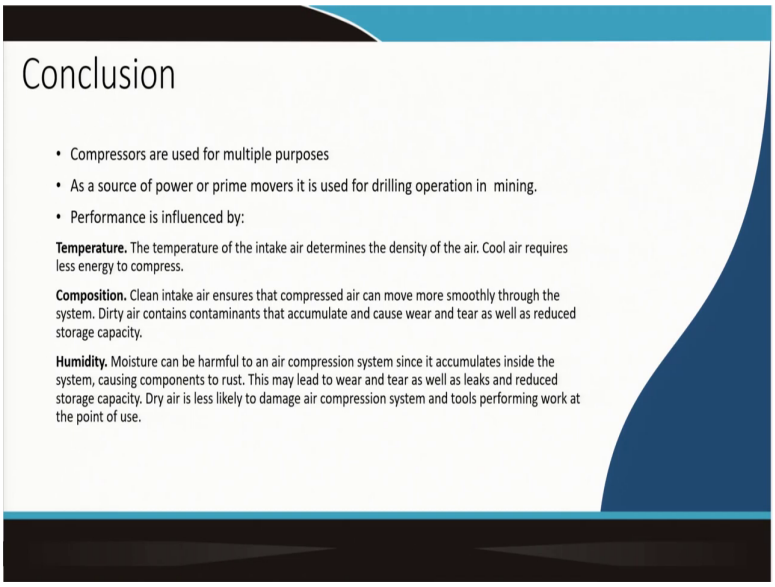


So, there are different ways how you can improve the performance of this compressor. So, as the conclude you must know that is a there is a multipurpose use of this. So, as a result you must know about how it works and what how you will do the up keepment of it. So, basically if you monitor the temperatures.

If you know the air compositions that is whatever air is coming out or going in, there should not be dirt, there should not be other things, sometimes a gaseous mix so depending on the situation, some that whatever the composition of air you are going to have the humidity, the temperatures that all will play a big role and you need to keep monitoring over here.

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So, there are these different references please go through how to make air your air compressor that is more efficiency, these references gives you a good idea and as a (Refer Time: 34:33) of a mines you should have a fair idea about this piece of equipment being used in the mines with this.

Thank you very much.