Chemical Process Utilities
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Lecture – 35
Material Properties and Pipeline Feeding Devices

Welcome to the material properties and pipeline feeding device under the edges of chemical process utilities.

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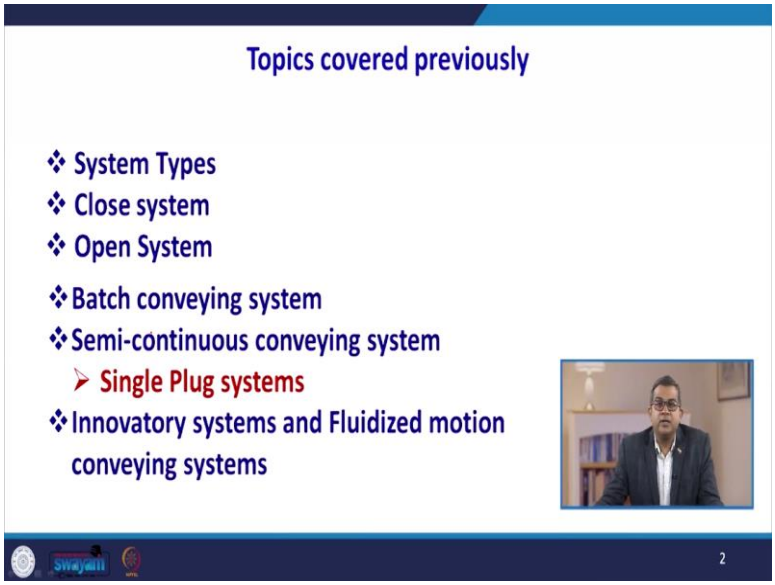

As you know we were discussing about the various pneumatic systems and conveying systems and in the previous lecture we discussed about the various conveying system types, close type system, open type system. We discussed about the batch conveying system, we had discussion about the semi continuous conveying system with a single plug system. We were described being about the innovatory system and fluidize motion conveying system.

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In this particular lecture we will discuss about the influences of material properties, what is the impact of different material properties on the conveying aspect then we will discuss about the pipeline feeding devices this inclusive of rotary valve, air leakage, entrainment devices, rotor type, feed rates etcetera.

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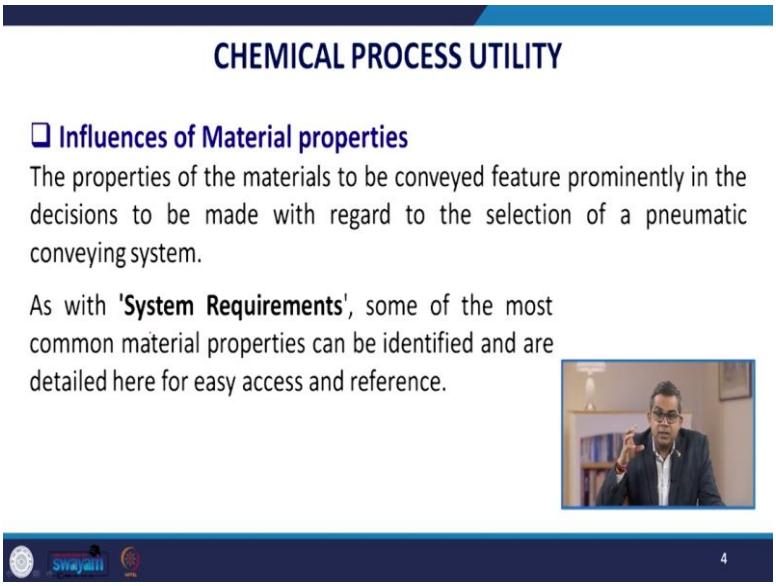

Now let us talk about the influences of material properties. The properties of the material to be conveyed feature prominently in the decision to be made with regard to the selection of pneumatic conveying system. See we discussed about the physical properties of material like fine particles, granular particles, we discussed about the various specification. So, all these properties they influenced about the selection because we had discussed the different type of pneumatic conveying system.

So, which type of pneumatic conveying system is used for what material that is important. So, as with the system requirement some of the most common material properties can be identified and we are going to discuss here for easy, access and reference.

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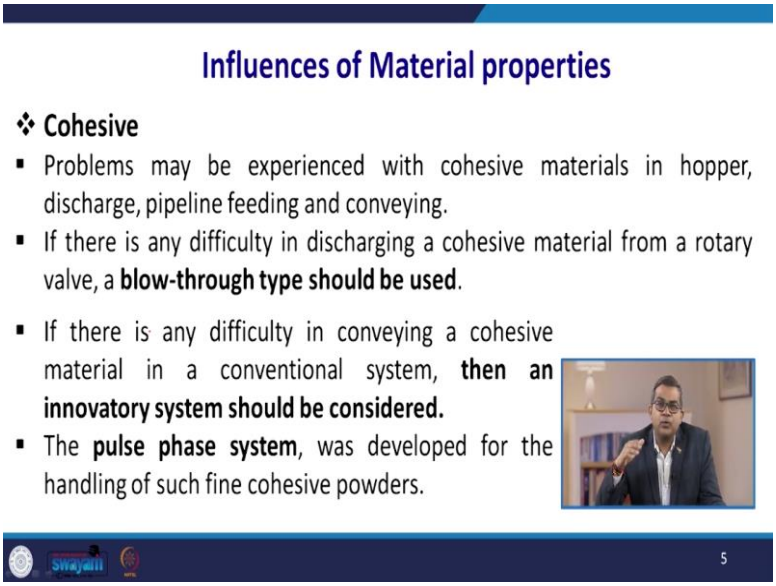

First one in this category is the cohesive properties under the influence of material properties. Now sometimes the problem may be experienced with cohesive materials in hopper. Discharge pipeline, pipeline feeding and conveying. If there is any difficulty in discharging a cohesive material from a rotary valve a blow through type should be used. Now, if there is any difficulty in conveying a cohesive material in conventional system then an innovative type of system should be considered. The pulse phase system this was deployed for the handling of such fine cohesive powders.

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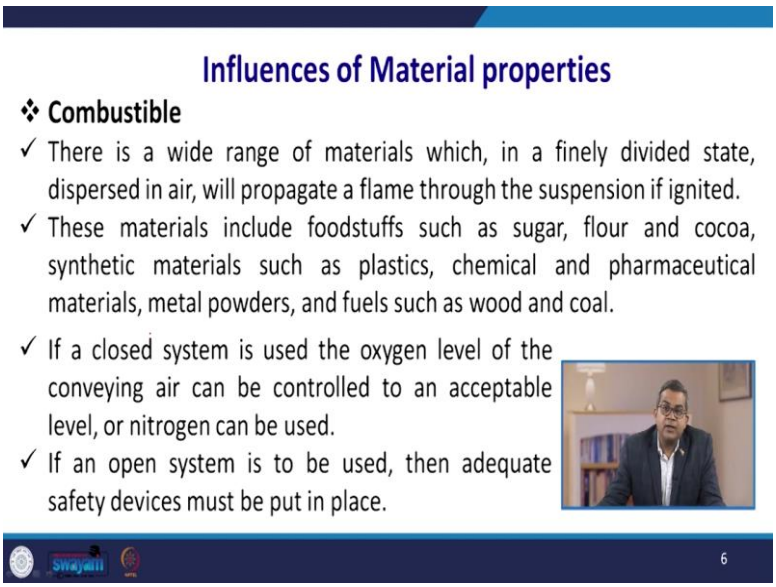

Another is again very important that is combustible. Now there is a wide range of materials which finally divided state, disperse in air they propagate a flame through the suspension if they ignited. So, due care must be taken while selection of the conveying system as well as conveying fluid. Now these materials include food stuff such as sugar, flour, cocoa, synthetic material such as plastic, chemicals, pharmaceutical materials, metal powders, fuel sometimes like wood and charcoal etcetera.

Now, if a close system is used the oxygen level of the conveying air can be controlled within acceptable level or nitrogen can be used because oxygen can promote the ignition however nitrogen is inert. Now, if an open system is to be used the adequate safety devices must be put in place. We have already discussed all those devices in previous lectures.

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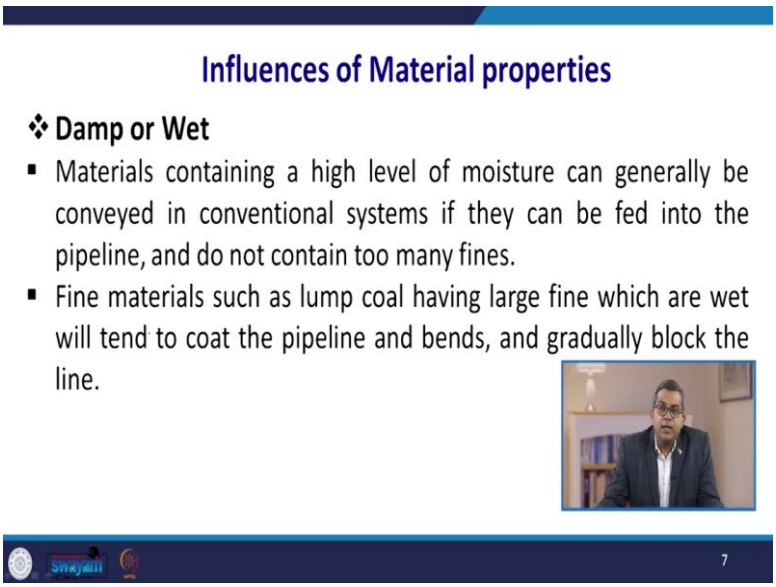

Another thing is the damp or wet that is again very important. Now material containing a high level of moisture can generally be conveyed in conventional system if they can be fed into the pipeline and they do not contain too many fines. Now fine materials such as lumps, coal they are having large fines which are wet because they are coming from mines. Now they tend to coat the pipeline and bend and gradually block the lines by gradual deposition to the inner surface of the pipeline valve.

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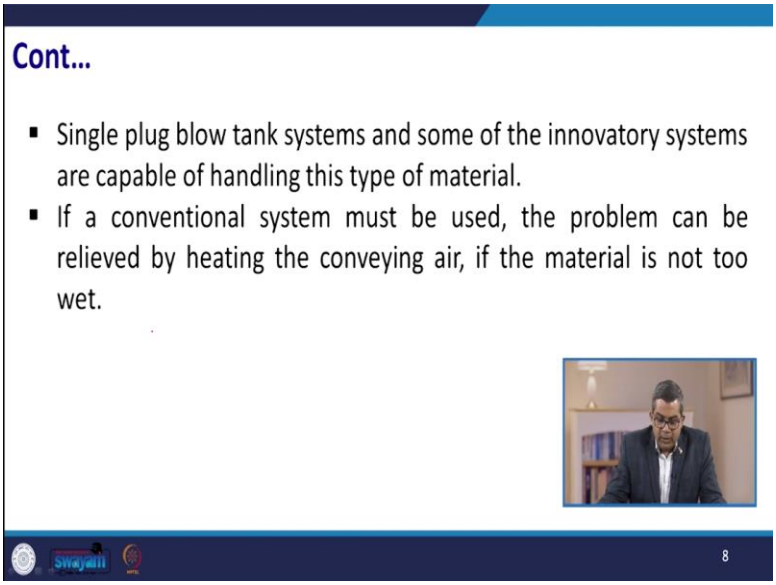

Now single plug blow tank system and some of the innovatory systems are capable of handling this type of material. If a conventional system is to be used the problem can be relieved by heating the conveying air if material is not too wet. So, we can overcome such kind of moisture within the material.

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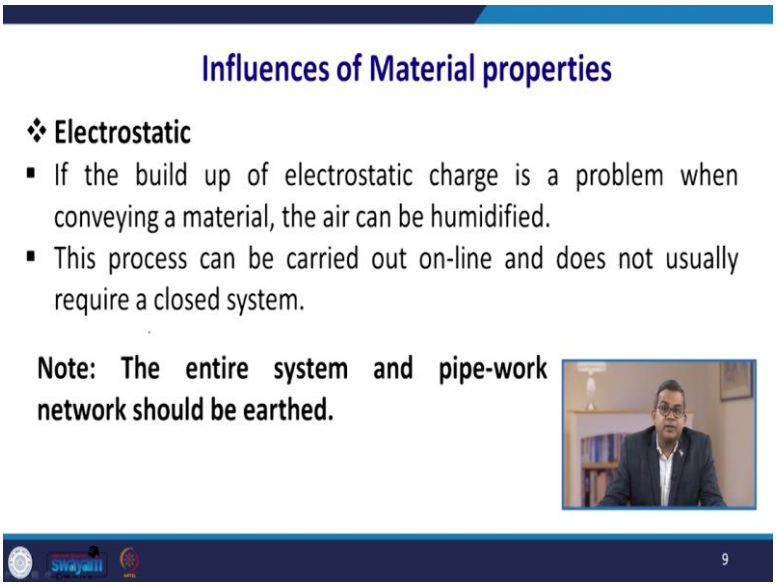

Another thing is that electrostatic. If the buildup of electrostatic charge. Sometimes due to friction the electrostatic charge may build up over the period of time and this is very problematic when the conveying material or air this can be humidified. Now this process can be carried out online and does not usually require a close system. The entire system in piping network should be earthed while handling such kind of material.

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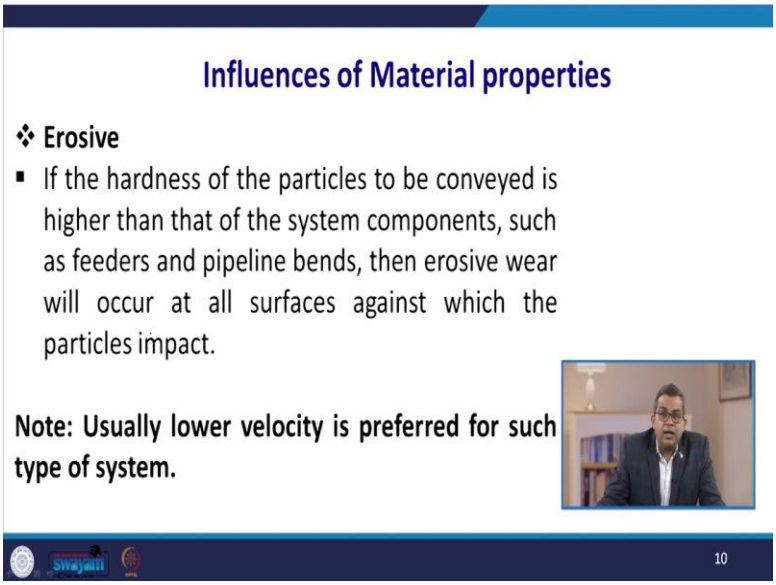

Another very important point is attributed to the erosive ness. Now, if the hardness of the particle to be conveyed is higher than that of the system component such as feeder, pipeline, bends then erosive wear will occur all surfaces against which the particles impact. Now usually lower velocity is preferred for such type of system.

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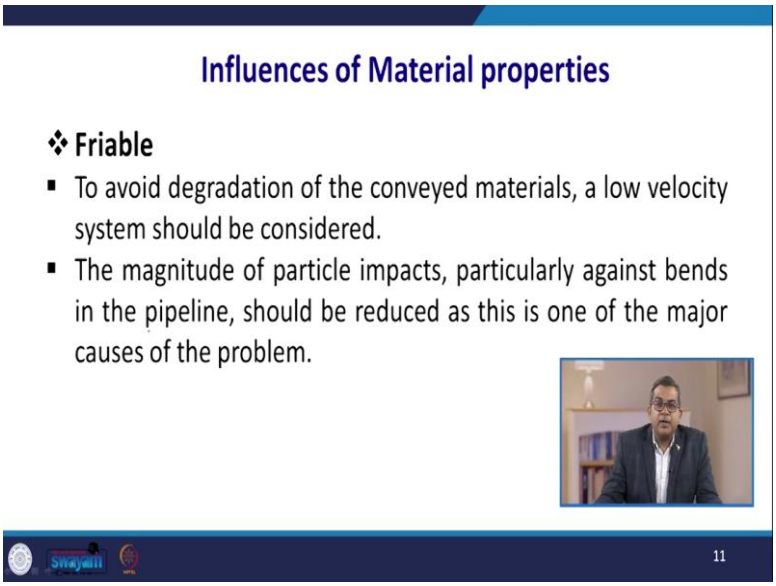

Friable now to avoid any kind of a degradation of the conveyed material a low velocity system should be considered. The magnitude of particle impacts particularly against bends in the pipeline should be reduced as this may create a problem of choking this may create further problem during the proper conveying of the material.

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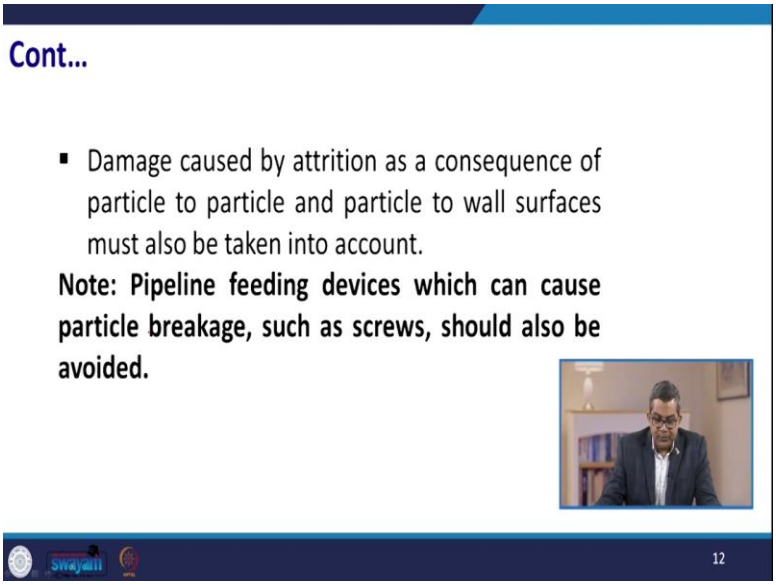

Damage cause by attrition as consequence of particle to particle and particle to wall surfaces must also be taken into account. Now pipeline feeding devices which can cause particle breakage such as screw this should also be avoided.

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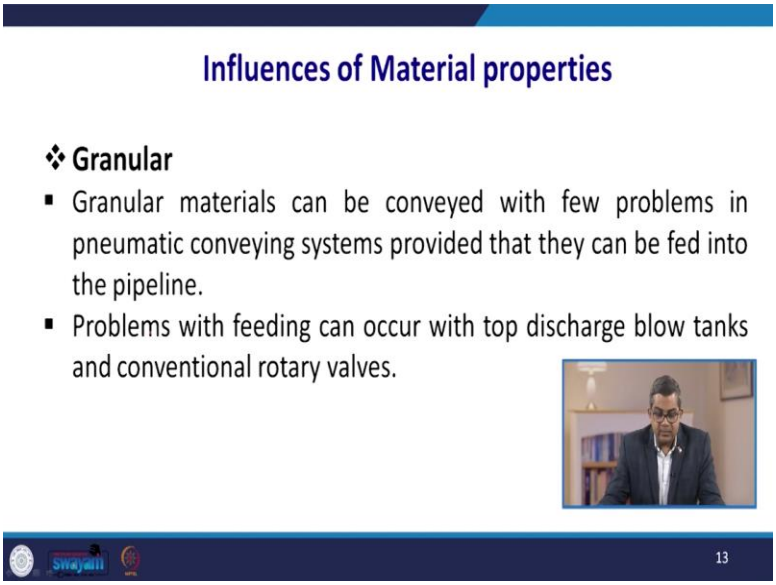

Now let us talk about the granular thing. Now granular materials can be conveyed with the few problems in pneumatic conveying system provided that they can be fed into the pipeline. Problems with the feeding can also be occur with the top discharge blow tanks and conventional rotary valves.

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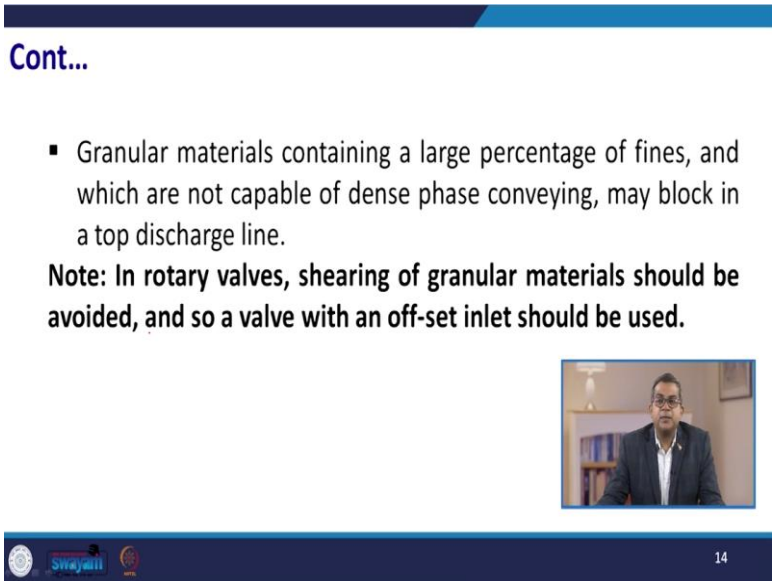

The granular materials containing a large percentage of fines and which are not capable of dense phase conveying may block in a top discharge line. Now, in a rotary valve sharing of granular material should be avoided. So, a valve with an offset inlet should be used in that particular case.

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There are certain materials which are hygroscopic in nature. So, if a material is hygroscopic then air whatever air being used for conveying it should be dried to reduce the moisture level to an acceptable level otherwise the material will observe the atmospheric moisture and the proper purpose of the system will not be fulfilled. Now this process can be carried out online and does not usually require a close system.

For a material which is slightly hygroscopic can be conveying if the material is conveyed in a dense phase without the use of air drying equipments.

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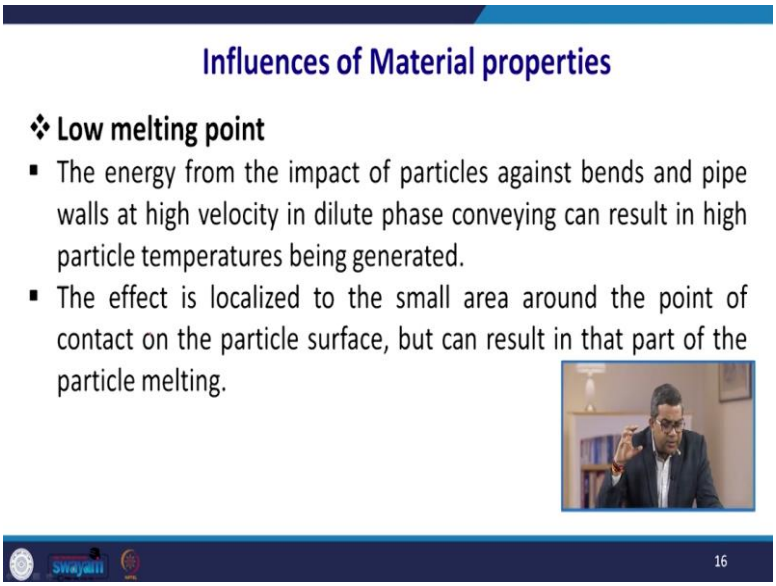

There are certain materials who possess low melting point. The energy from the impact of particles against bends and pipe walls at high velocity in dilute phase conveying this can result in high particle temperatures being generated. The effect is localized by a small area around a point of contact on the particle surface, but can result in that part of the particle melting.

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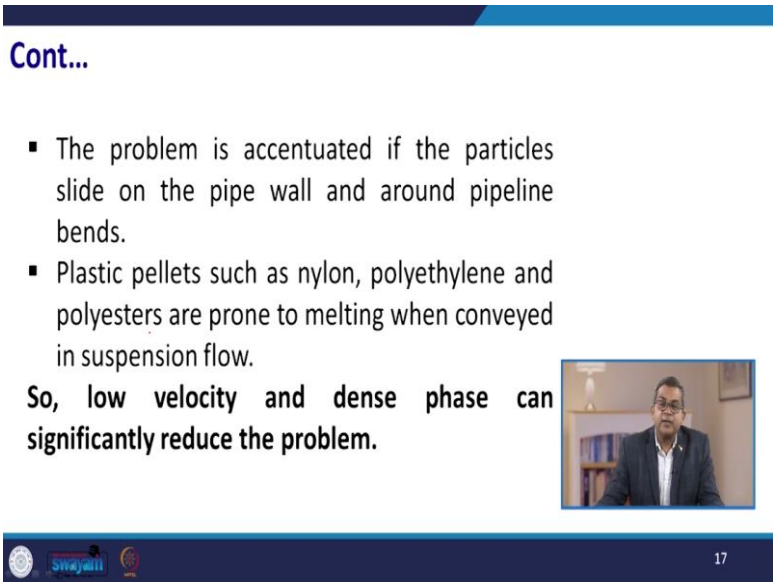

The problem is accentuated if the particle slides on the pipe wall and around pipeline bend. Plastic pellets such as nylon, polyethylene, polyester they are prone to melting when conveyed in suspension flow. So, low velocity and dense phase can significantly reduce the problem.

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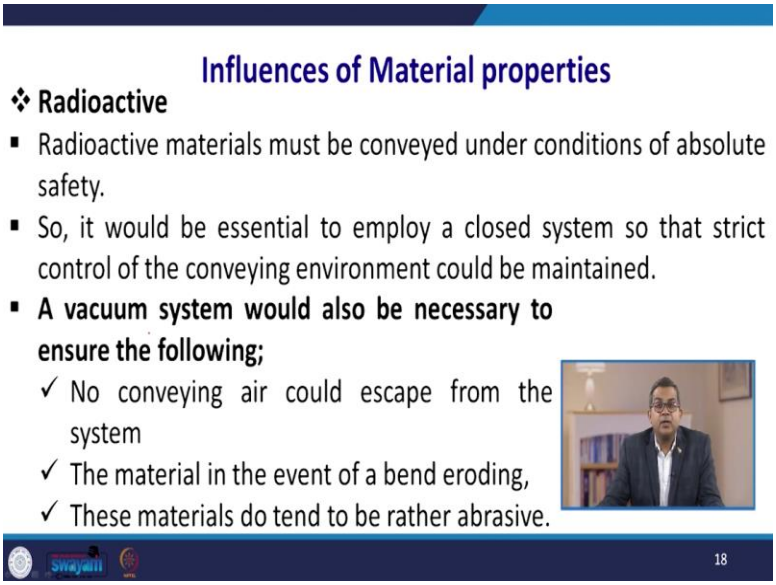

There are certain materials to posses the radio activeness and they must be handled very carefully. The radioactive materials they must be conveyed under condition of absolute safety and their safety nature is entirely different what we have discussed earlier. So, it would be essential to employ a closed system so that strict control of the conveying environment can be maintained.

And you may have proper control to the system because any kind of leakage may be very dangerous to the environment as well as the person those who are working around. A vacuum system would also be necessary to ensure that there is no conveying air could escape from the system because it may carry the radio activeness to the atmosphere. The material in the event of bend may be eroding.

These materials usually do not tend to be rather abrasive. There are certain the conveying of toxic material in the process industries is quite common. So, if toxic materials are to be handled strict control of working environment must be maintained like vacuum system, conveying air after filtration because overall objective is to prevent the escape of those material to the atmosphere or open system would be satisfactory.

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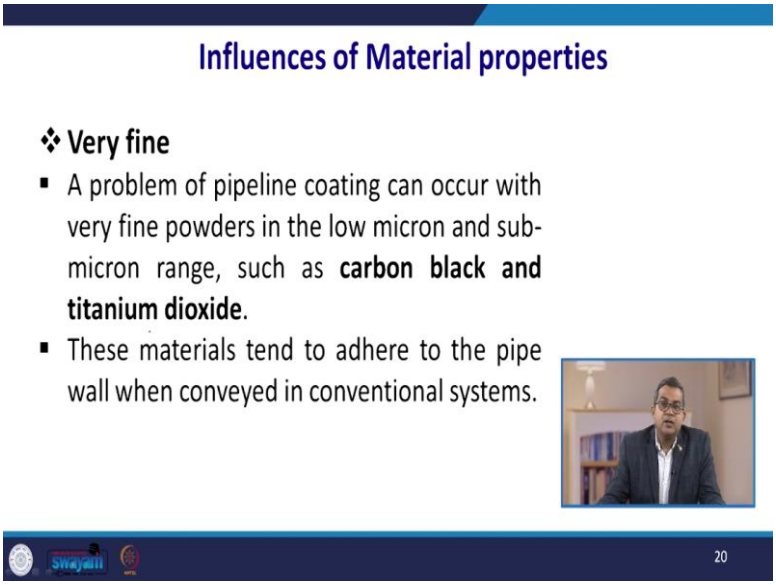

There are certain particles which posses a very fine nature. A problem of pipeline coating can occur with very fine powders in the low micron and sub micron range such as carbon black, titanium dioxide. These materials they have tendency to adhere to the pipe walls when conveyed in a conventional type of system.

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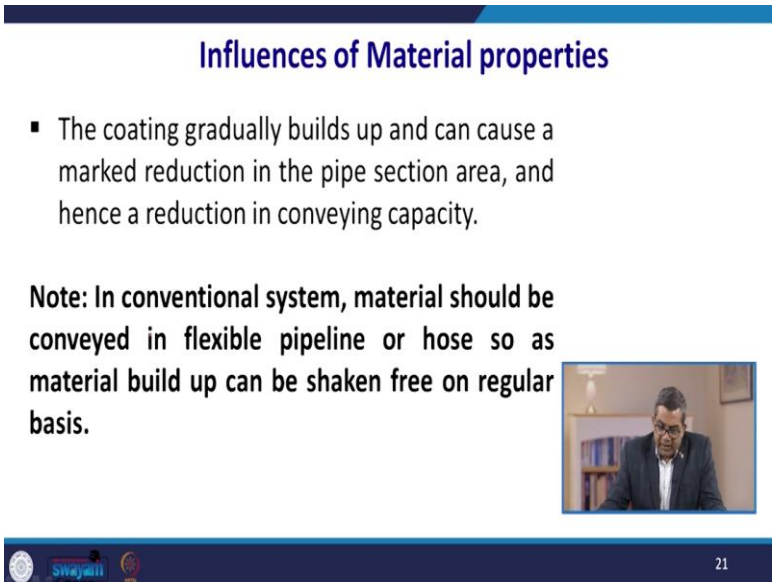

The coating gradually builds up and can cause a marked reduction in the pipe section area and reduction in conveying capacity. In conventional system material should be conveyed in flexible pipeline or hose so as material build up can be shaken free on regular basis.

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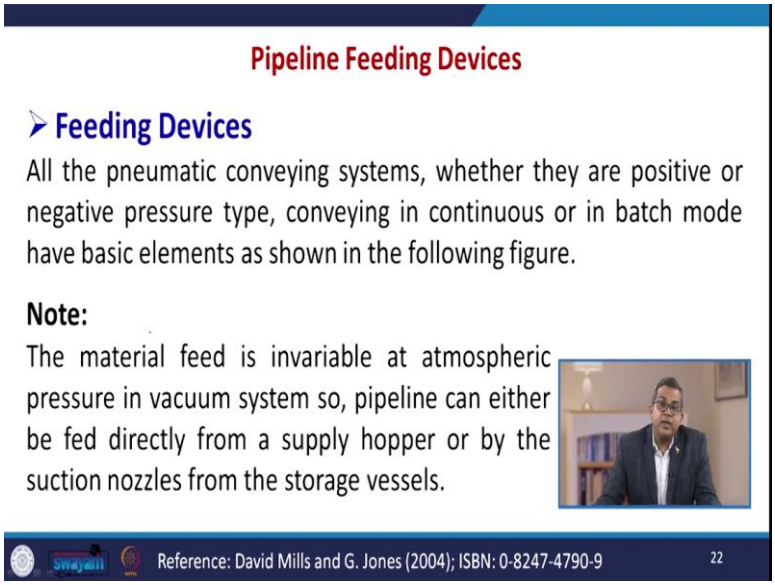

Now pipeline feeding devices are again very important while considering the conveying system. So, all the pneumatic conveying system whether they are positive or negative pressure type conveying in continuous or in batch mode they have the basic elements in all the type of system. Now the material feed is invariable at atmospheric pressure in vacuum system.

So, pipeline either can be fed directly from the supply hopper or by the suction nozzle from the storage vessel.

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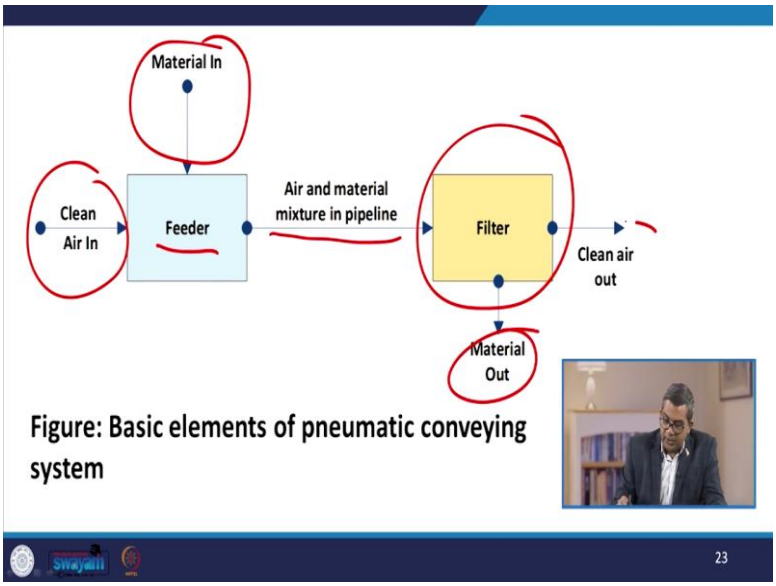

You have seen over here these are the basic elements of pneumatic conveying system. We are passing the material from one port and we have the cleaning air in the other port. Now this is the feeder system and air and material in combination or in the mixture form it subjected to the

pipeline and this is subjected to the filter where material is coming out and a clean air is going out.

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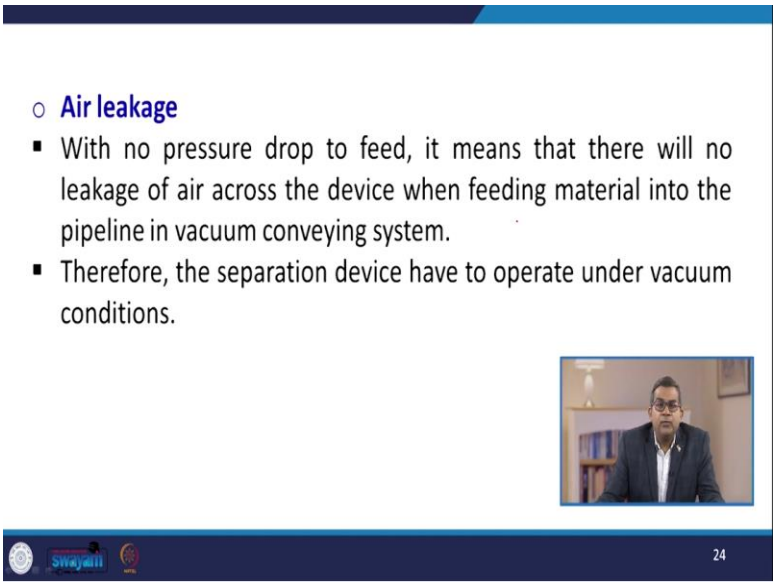

Now sometimes you may experience the air leakage with no pressure drop to feed it means that there will be no leakage across or no leakage of air across the device when feeding material into the pipeline in vacuum conveying system. Therefore, the separation devices have to operate under vacuum condition.

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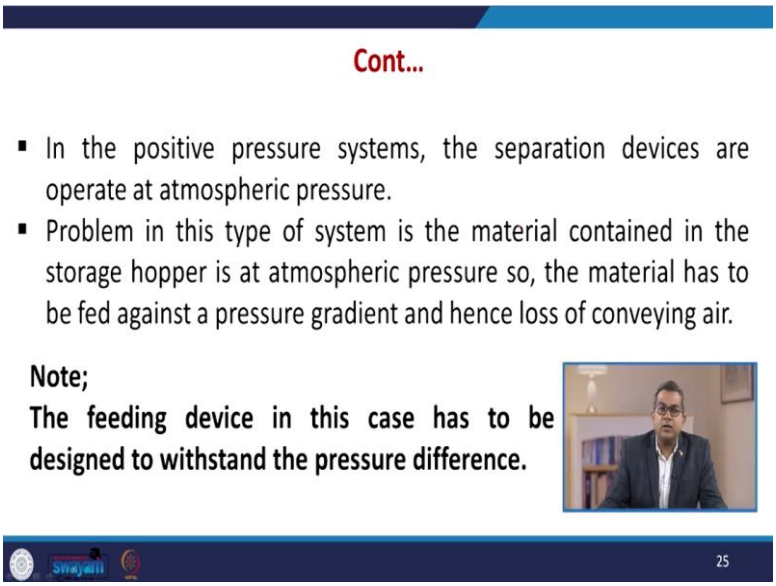

Now in the positive pressure system the separation devices are operate at atmospheric pressure. Problem in this type of system is the material contained in the storage hopper is at atmospheric pressure. So, the material has to be fed against a pressure gradient hence the loss of a conveying

air. The feeding device in the particular case has to be designed or withstand the pressure difference.

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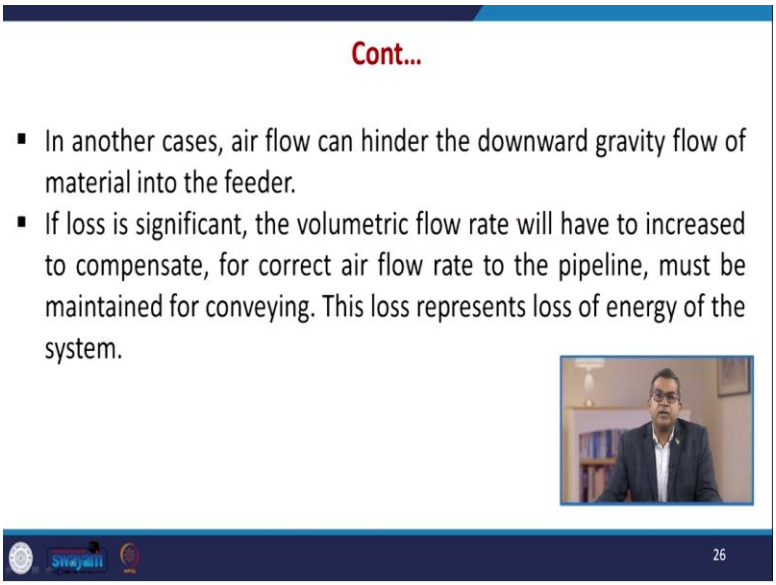

In another case air flow can hinder the downward gravity flow of material into the feeder. Now, if the loss is significant the volumetric flow rate will have to increase to compensate for correct air flow rate to the pipeline and it must be maintained for conveying throughout. The loss represents loss of energy of the system.

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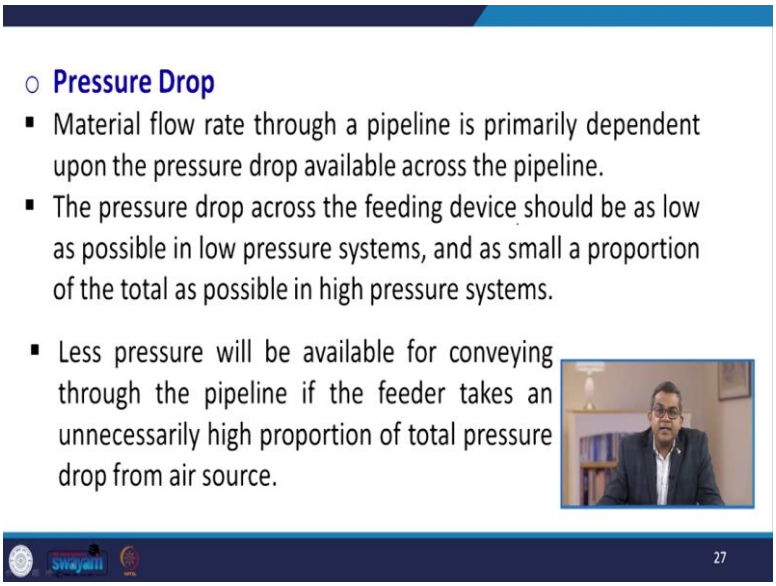

There may be certain pressure drops across the thing. The material flow rate through a pipeline is primarily dependent on the pressure drop available across the pipeline. The pressure drop across the feeding device should be as low as possible in low pressure system and as small proportion of the total as possible in the high-pressure system. Less pressure of course will be

available for conveying through the pipeline if the feeder takes in unnecessary high proportion of total pressure drop from air source.

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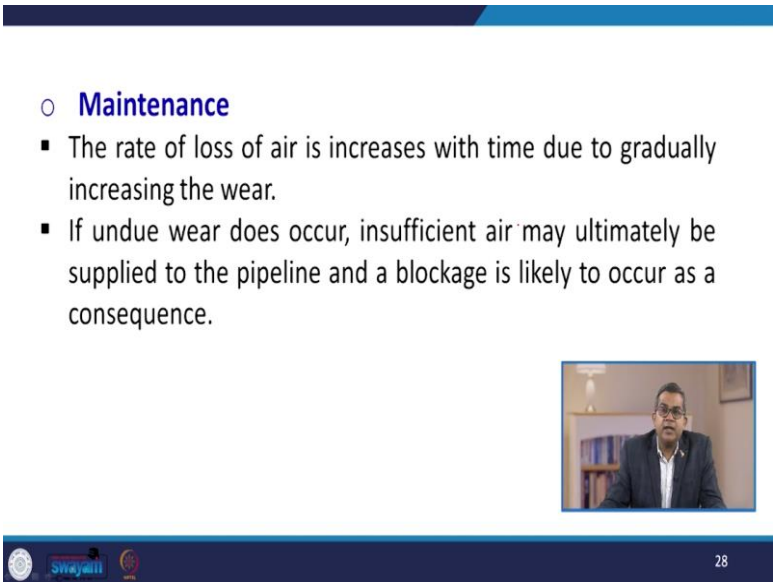

Now maintenance is very crucial aspect as far as this type of system is in question. So, the rate of loss of air is increases with time due to gradually increasing the wear. If undue wear does occur insufficient air may ultimately be supplied to pipeline and blockage is likely to occur as a consequence and that may create some economic loss because of the blockage may require some more electrical power with respect to the pumping.

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Now when we talk about the material properties it is important to have to be taken into account in the selection of feeding devices. Now in feeding system that have moving parts, care has to be taken with both abrasive and friable materials. Material flow properties and particle size

also need to be taken into account with feeding devices. Particularly in two extreme cases such as larger particle size and pellets, very fine and powdered material.

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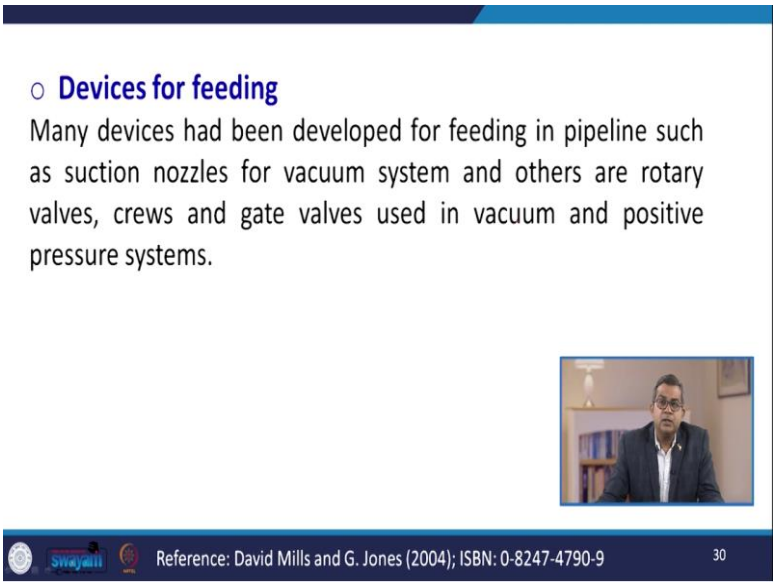

Now let us talk about the devices for feeding. Many devices had been developed in past for feeding in pipeline such as suction nozzles for vacuum system and others are rotary valves, crews, gate valves used in the vacuum and a positive pressure system.

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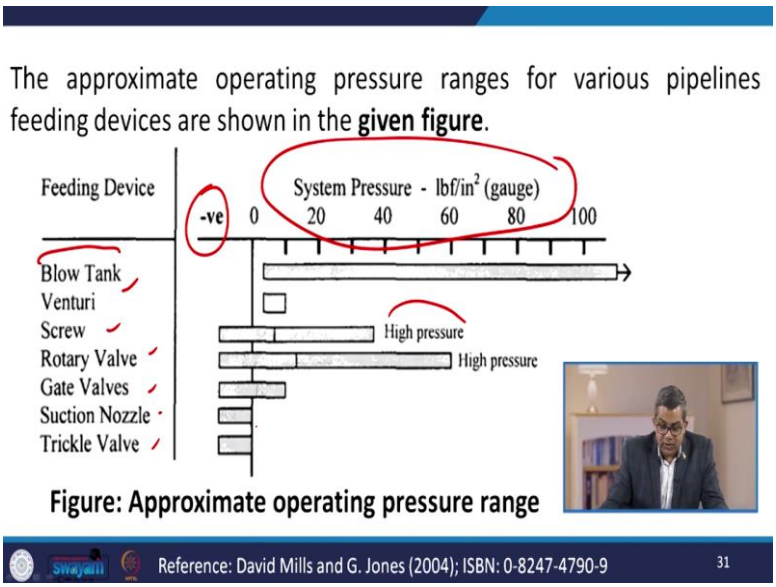

Now the approximate operating pressure ranges for various pipeline feeding devices as shown here. Now here you see this is the system pressure. Now blow tank, Venturi, screw, rotary valves, gate valves, suction nozzle, trickle valves these are some of the feeding devices and we see that here we are having negative pressure and high pressure. So, as per the requirement can

use different type of feeding devices and you can indicate the pressure range or system pressure (()) (17:36) square gauge.

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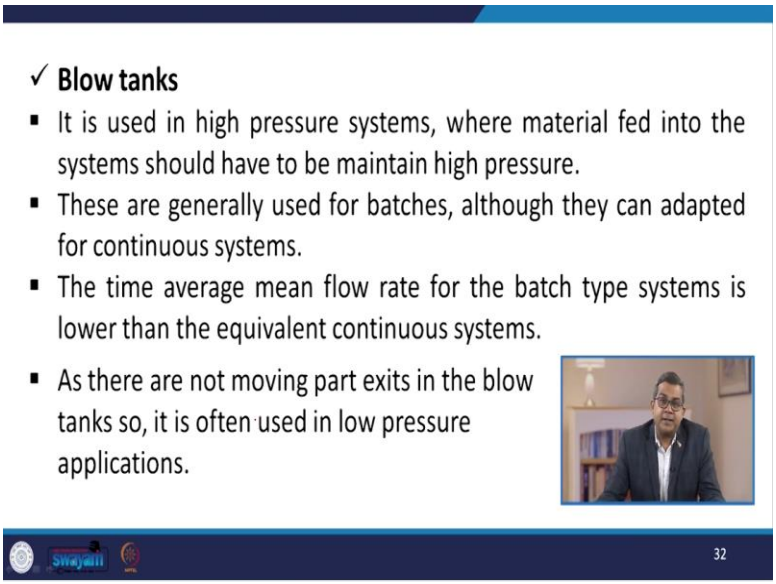

Now, let us have a look about the blow tanks. Now, it is used in high pressure system where material fed into the system should have to be maintained at high pressure. These are generally used for batches although they can be adopted for continuous system. The time average mean rate for the batch type system is lower than the equivalent continuous system as there are not moving part exist in the blow tank so it is often used in low pressure application.

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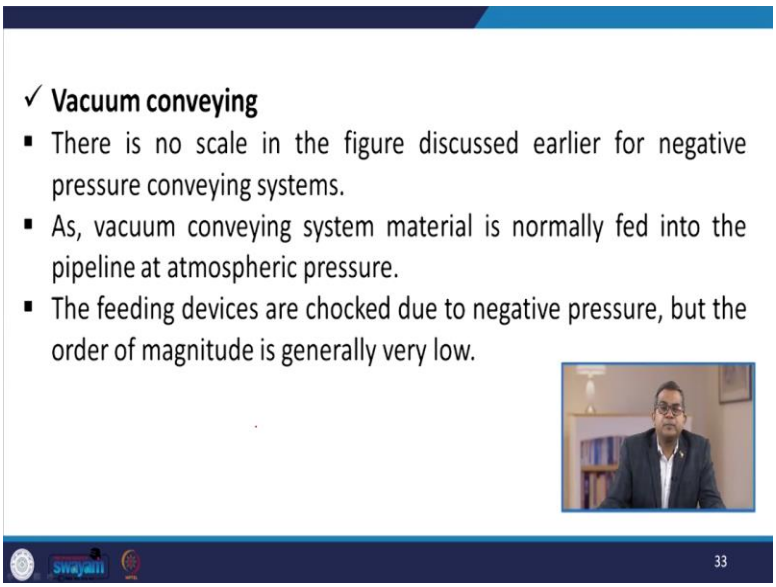

Let us talk about the vacuum conveying. There is no scale in the figure discussed earlier for negative pressure conveying system. As a vacuum conveying system material is normally fed

into the pipeline at atmospheric pressure. The feeding devices are chocked due to negative pressure, but the order of magnitude is generally very low.

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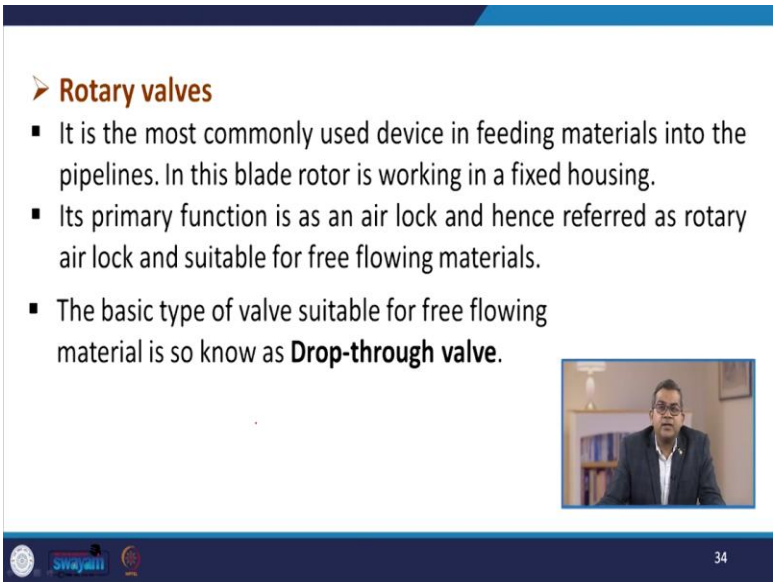

Rotary valves; it is the most commonly used device in the feeding material into the pipeline. In this blade rotor is working in fixed housing. It is primary function is air lock therefore hence referred as rotary air lock and suitable for free-flowing materials. The basic type of valve suitable for free-flowing material is also known as drop through valve.

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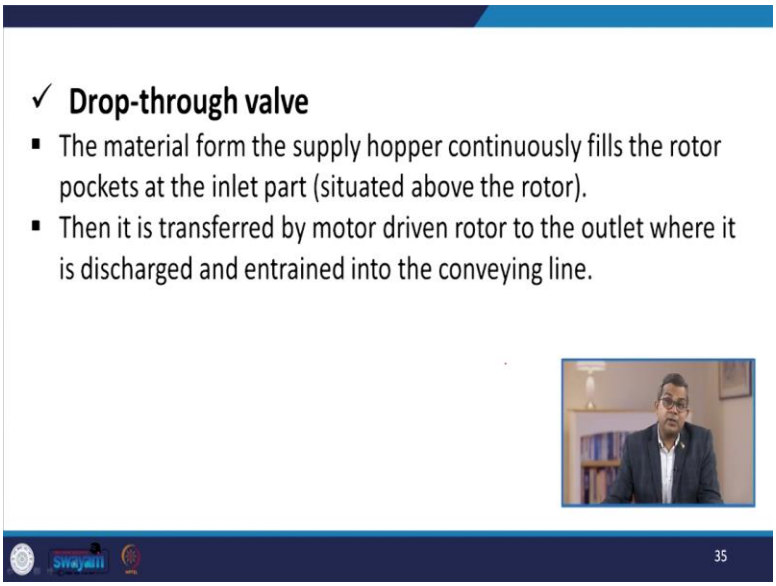

Now again we introduce the word drop through valve then it is responsibility to have a word about the drop through valve. The material from the supply hopper continuously fills the rotor pockets at the inlet part just situated above the rotor. Now then it is transferred by motor driven rotor to the outlet where it is discharged and entrained into the conveying line.

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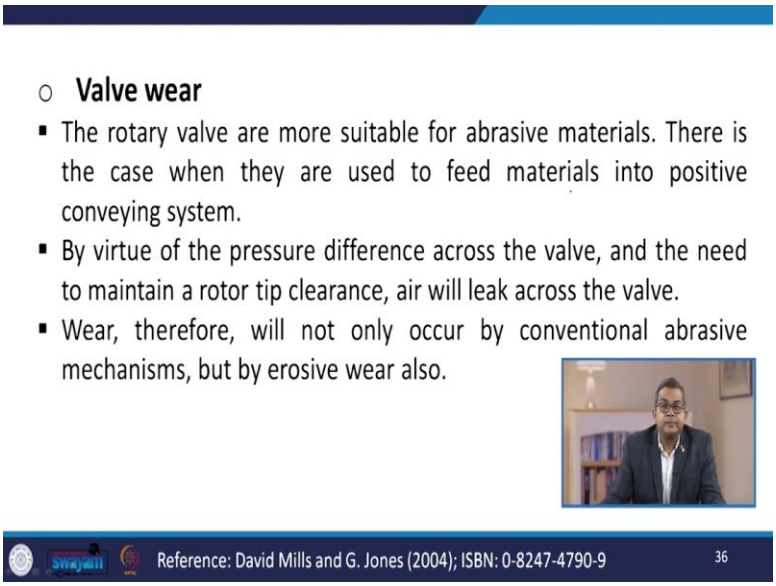

Valve wear the rotary valve are more suitable for abrasive materials. Now there is a case when they are used to feed materials into positive conveying system. By virtue of the pressure difference across the valve and the need to maintain a rotor tip clearance air will leak across the valve. Wear therefore will not only occur by conventional abrasive mechanism, by the erosive wear also.

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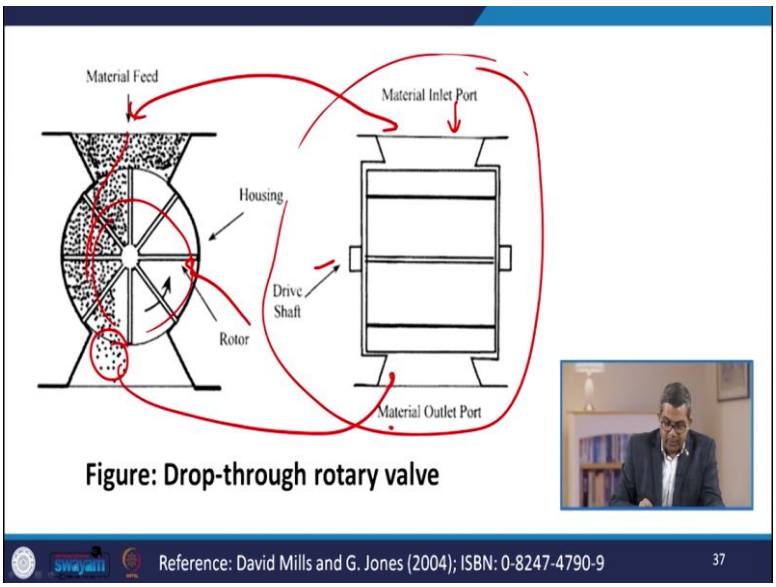

Now here you see the drop through rotary valves material is being fed over here and this subjected to the rotary motion and it is the drop and with the help of this rotor the rotary motion is carrying out and you see that this is the sketch of this drop through rotary valve. Here we are having this drive shaft and this is the material inlet port and this is the material outlet port and it is moving just like in this direction.

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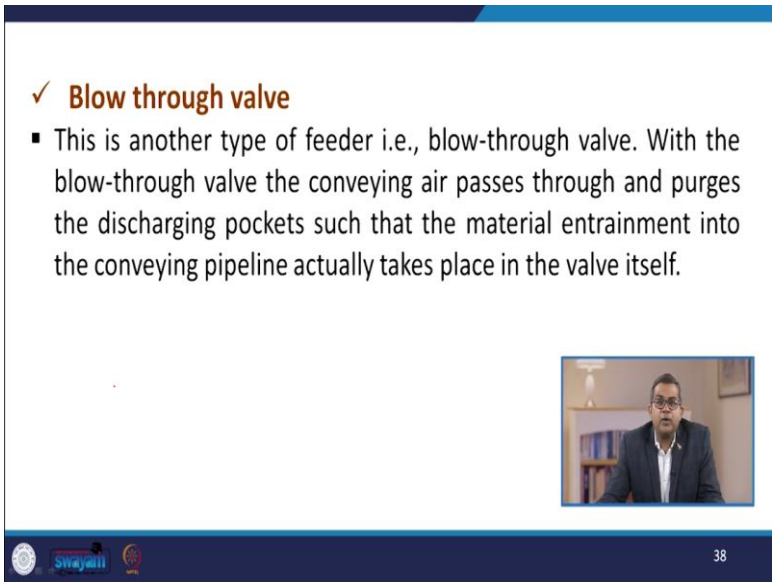

Let us talk about the blow through valve. Now this is another type of feeder that is the blow through valve. With the blow through valve for conveying air passage through and purges the discharging pockets such that the material entrainment into the conveying pipeline. This actually takes place in the valve itself.

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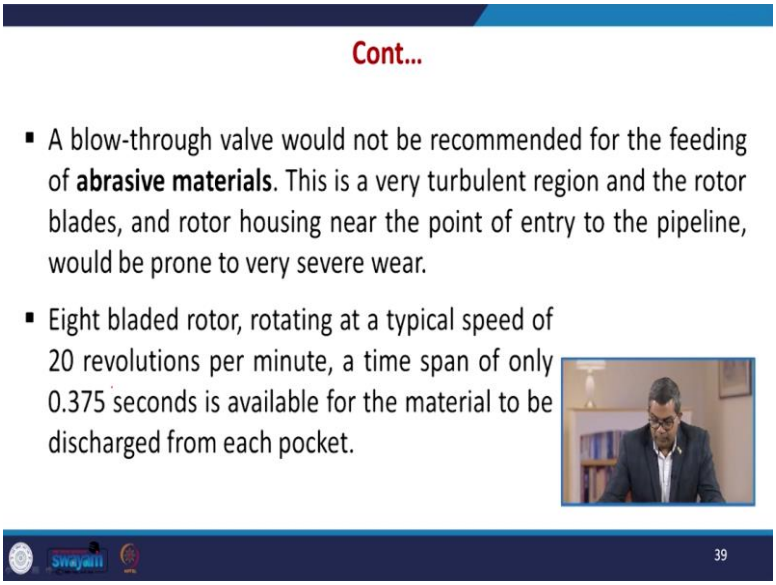

Blow through valve would not be recommended for the feeding for any kind of abrasive material. This is very turbulent region and the rotor blades and the rotor housing near the point of entry to the pipeline would be prone to very severe wear. Sometimes eight bladed rotors rotating at a typical speed of say 20 RPM or revolution per minute. A time span of only 0.375 seconds usually is available for the material to be discharged from each pocket.

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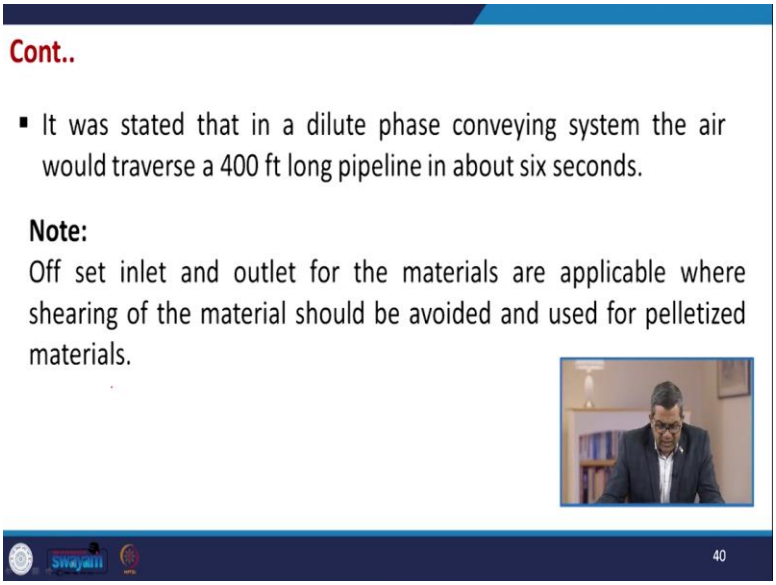

Now, it was stated earlier that dilute phase conveying system the air would traverse for 400 feet long pipeline in about 6 seconds. So, offset inlet and outlet for the material are applicable where shearing of the material should be avoided and used for palletized material.

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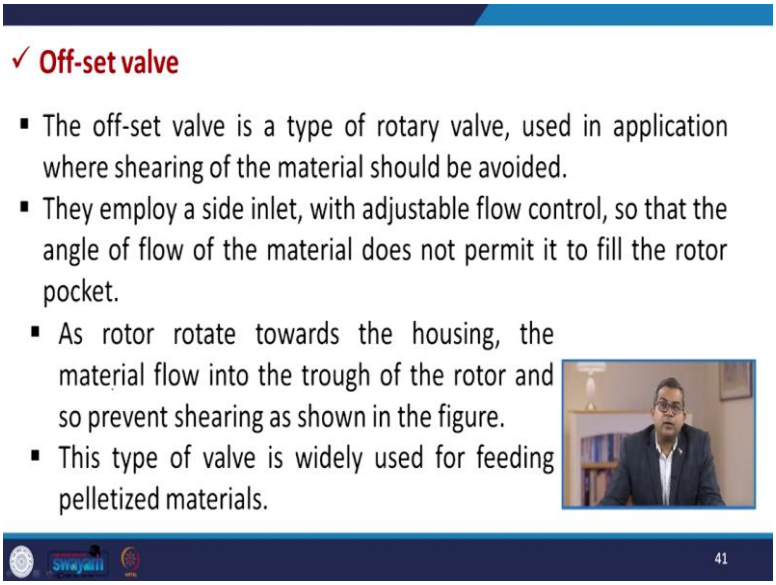

Now, let us talk about the off-set valve. The off-set valve is a type of rotary valve used in application where shearing of the material should be avoided. Now they employ a side inlet with adjustable flow control so that the angle of flow of material does not permit it to fill the rotor pocket. Now as the rotor rotates towards the housing the material flow into the trough of the rotor and so prevent shearing represented in the figure. Now this type of valve is widely used for feeding palletized material.

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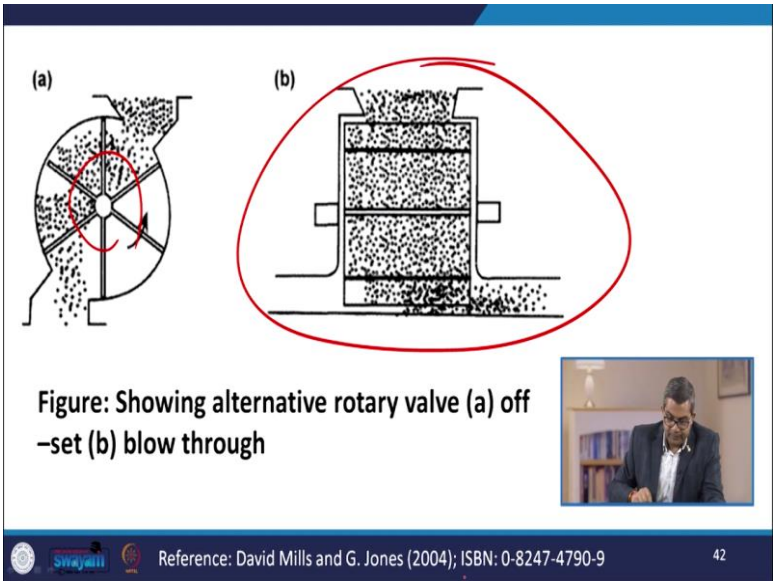

Now here you can see the figure which we were referring about. The rotor movement is just like this and this is the typical anatomy of the subsection of this rotary valve. Now, this is the off-set and this is the blow through.

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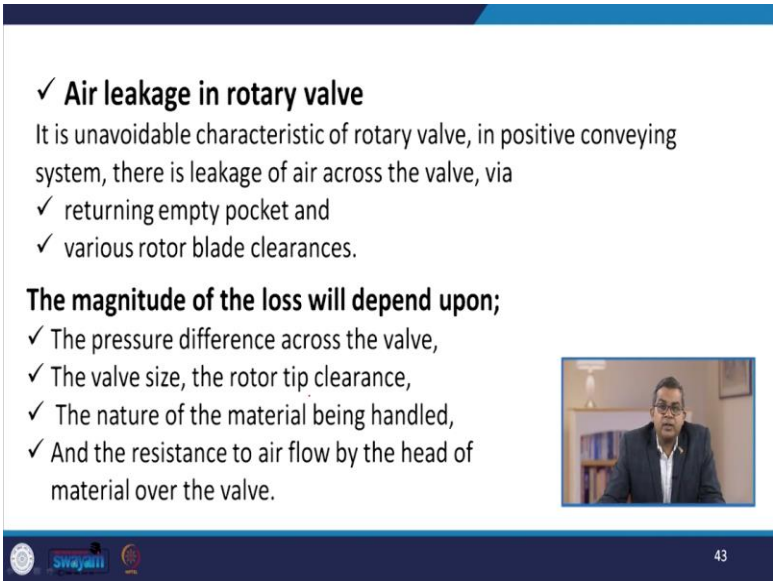

Now air leakage in the rotary valve it is we can say the phenomena need to be addressed. Now, it is unavoidable characteristics of rotary valve in positive conveying system. There is a leakage of air across the valve via returning empty pocket and various rotor blade clearances. Now when we talk about the loss then the magnitude of the loss it depends on the what is the pressure difference across the valve.

It depends on the valve size, the rotor tip clearance, the nature of the material being handled and the resistance to air flow by the head of the material over the valve.

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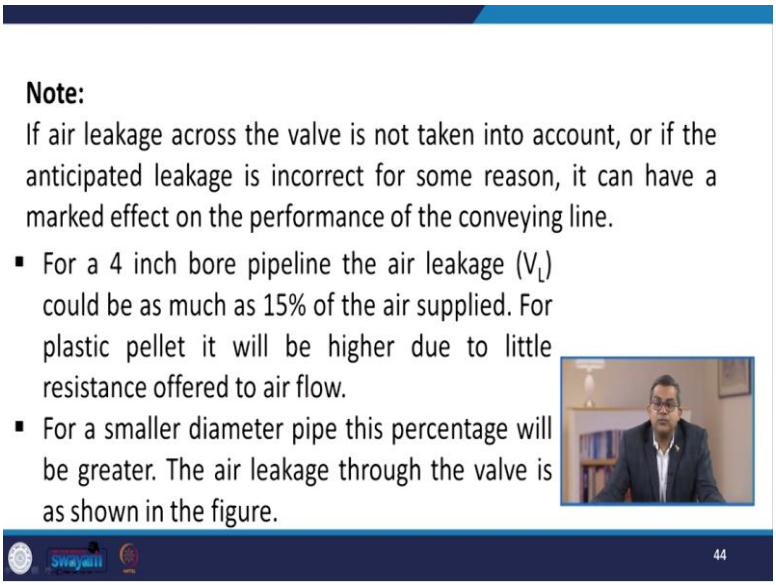

Now, if air leakage across the valve is not taken into consideration or if the anticipated leakage is incorrect for some reason, it can have a marked effect on the performance of the conveying line. For instance, for a 4 inch bore pipeline the air leakage say V L could be as much as say 15% of the air supplied. For plastic pellet it will be higher due to little resistance offered to air flow.

For a smaller diameter pipe this percentage will be greater. The air leakage through the valve is reflected in this particular figure.

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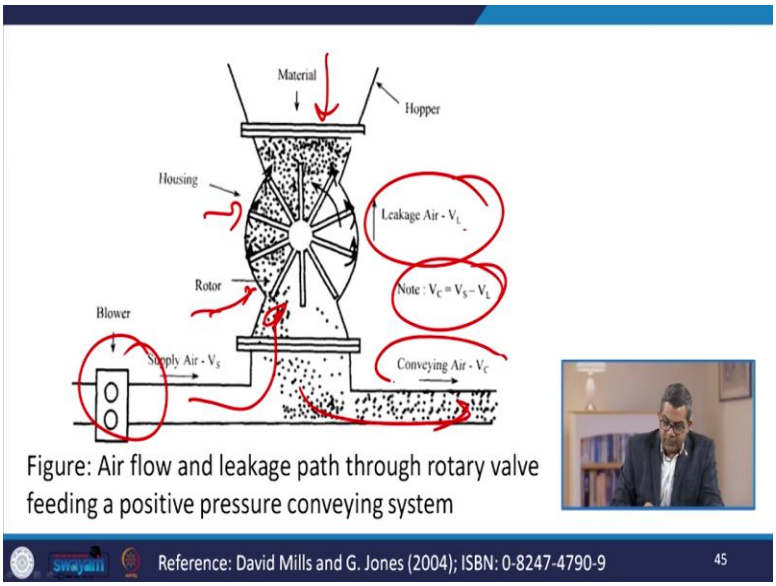

Now here you see we are feeding the material and material is coming out from here. This is subjected to the rotor and housing as depicted previously with the help of blower you are

supplying the air to the system. Now, if we consider the leakage of air that is V L so V C = V S – V L where V C is the conveying air.

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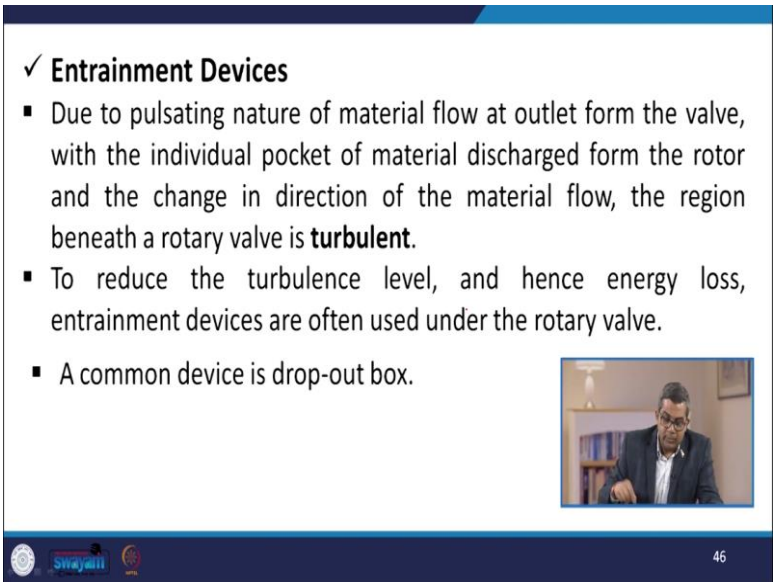

Now sometimes we look into the entrainment devices. Now due to pulsating nature of material flow at outlet form the valve with the individual pocket of material discharged from the rotor and the change in the direction of the material flow the region beneath rotary valve is turbulent. Now to reduce this turbulence or to reduce the turbulence level and there are subsequent energy loss the entrainment devices are often used under the rotary valve.

Common such type of devices drops out box and another configuration is the Venturi entrainment section. Here the cross-sectional area of air supply pipeline is reduced by means of a convergent section immediately prior to the rotary valve. Now as a result there is a corresponding increase in entrainment velocity and therefore a decrease in pressure in the region beneath the valve.

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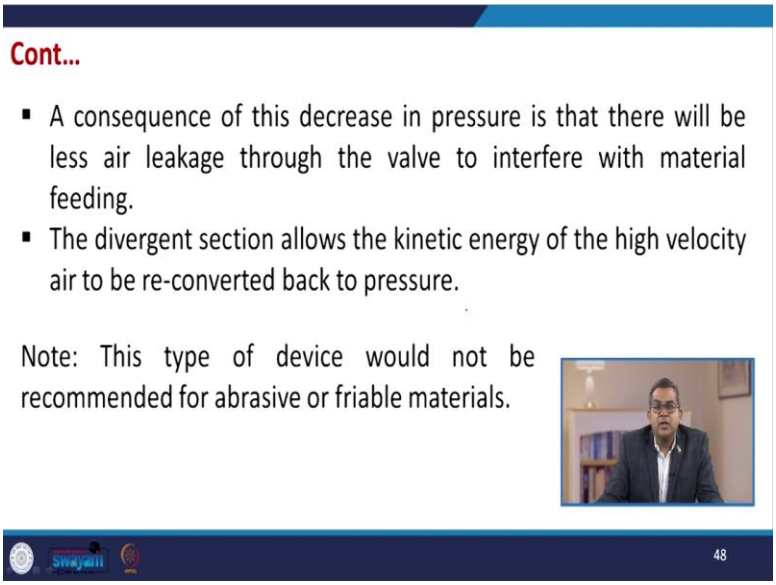

A consequence of this decrease in pressure is that there will be a less air leakage through the valve to interfere with the material feeding. The divergent section this allows the kinetic energy of high velocity air to be reconverted back to pressure. Now this type of device would not be recommended for abrasive or friable materials.

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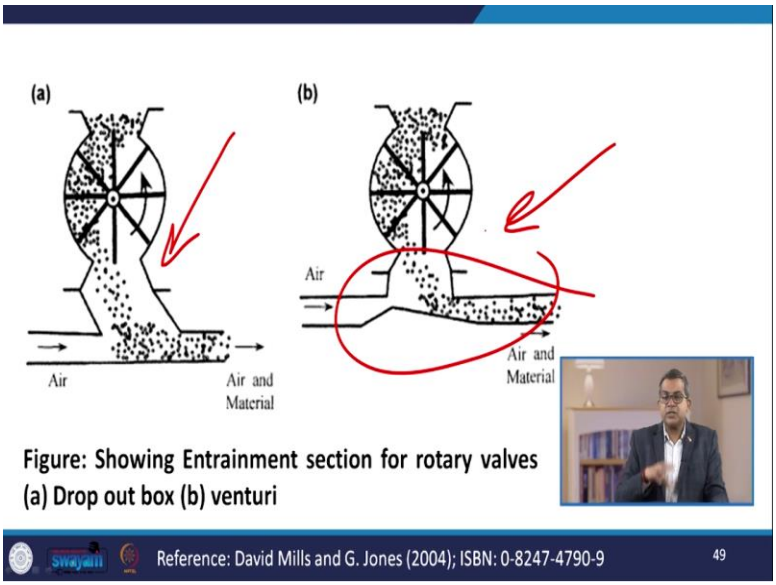

Now here you see that the entrainment section of rotary valves. Now here this is the drop out box and this is the Venturi and rest other function is common.

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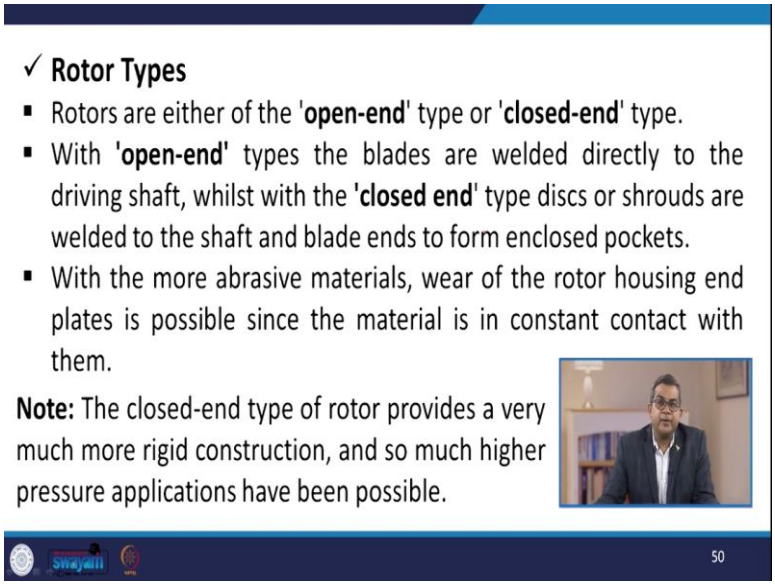

Now, let us talk about the rotor types. Rotors are either of open-end type or close end type. With open end types the blades are welded directly to the driving shaft while with the close end type discs or shrouds are welded to the shaft and blade ends form the enclosed pocket. With the more abrasive materials wear of the rotor housing end plates is possible since the material is constant contact with them.

So, the closed end type of rotor provides a very much more rigid construction and so much high-pressure application have been possible.

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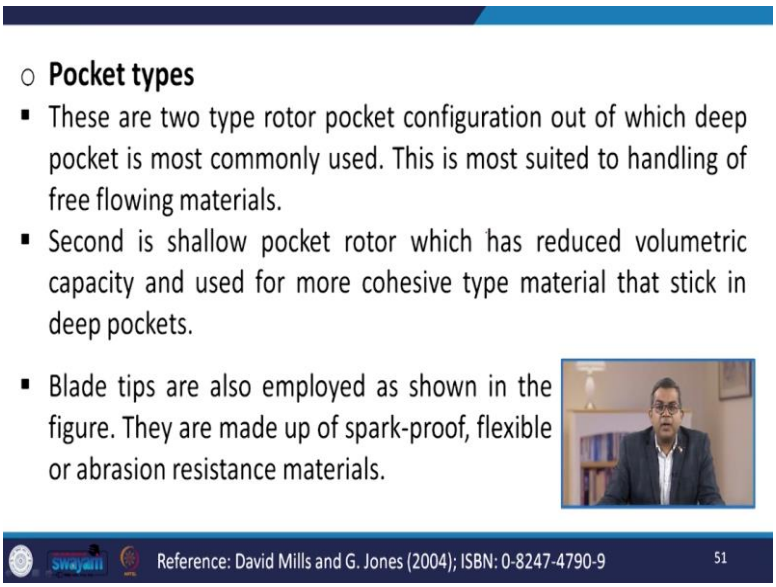

Pocket types now these are two type rotor pocket configurations out of which deep pocket is more commonly used. Now this is more suited to handling of free-flowing materials. Now second is the shallow pocket rotor which has reduced volumetric capacity and used for more

cohesive type of material that stick in the deep pockets. Now blade tips are also employed as you can see in this particular figure. They are made up of spark proof, flexible or abrasive resistance materials.

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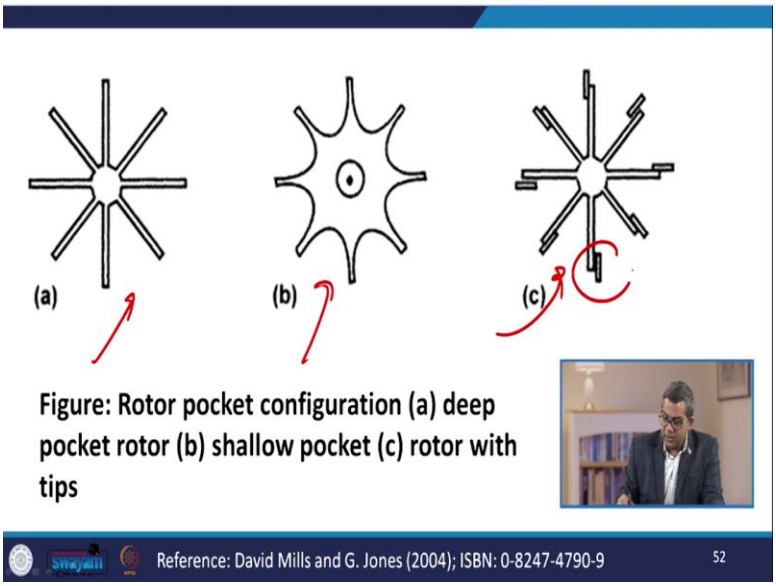

Now you see different type of rotor pocket configuration. This is the deep pocket rotor, shallow pocket and rotor with tips here you see the different tips.

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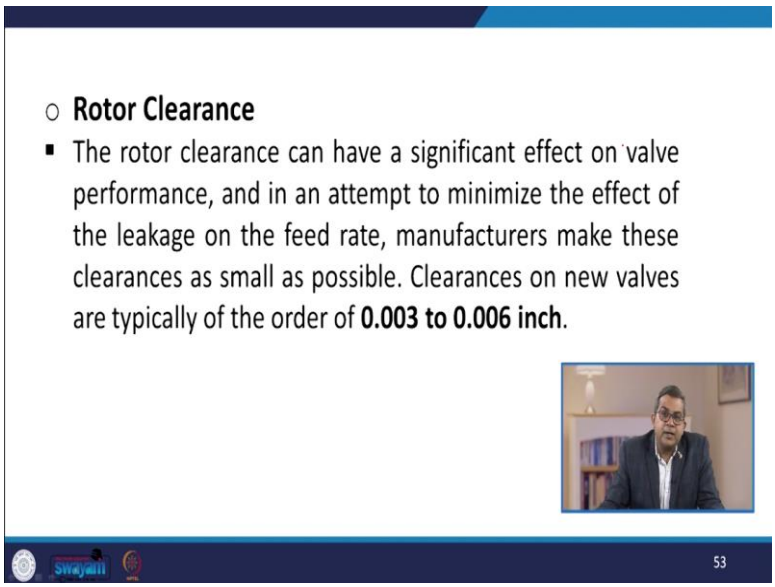

Now next is the rotor clearance. The rotor clearance can have a significant effect on valve performance and in attempt to minimize the effect of the leakage on the feed rate. Manufactures may make these clearances as small as possible. Now clearances on new valves they are typically in the order of 0.003 to 0.006 inches.

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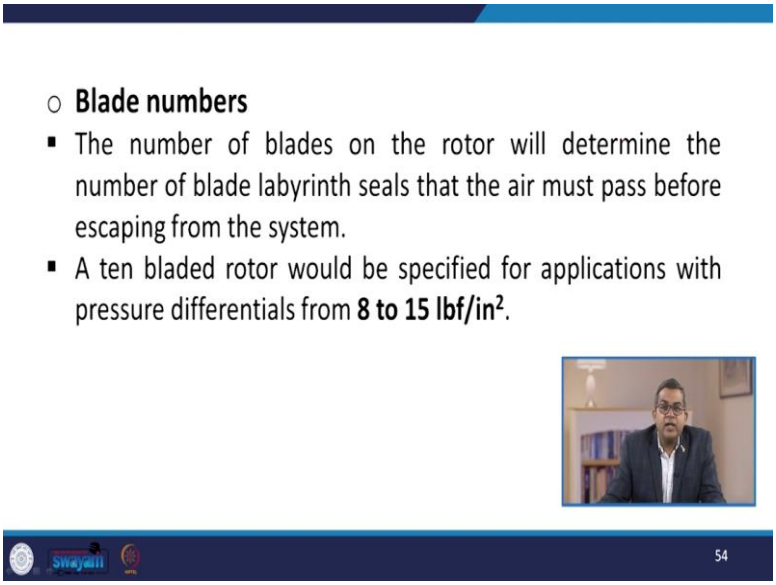

Then the blade number, the number of blades on the rotor will determine the number of blade labyrinth seals that the air must pass before escaping from the system. A ten bladed rotor would be specified for applications with pressure differential from 8 to 15 pounds force per inches square.

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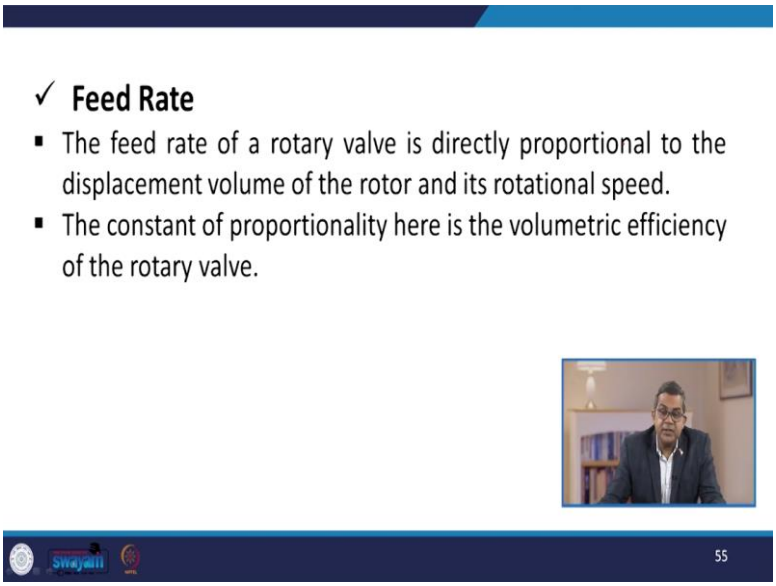

Then feed rate the feed rate of rotary valve is directly proportional to the displacement volume of the rotor and its rotational speed. The constant of proportionality here is the volumetric efficiency of the rotor valve.

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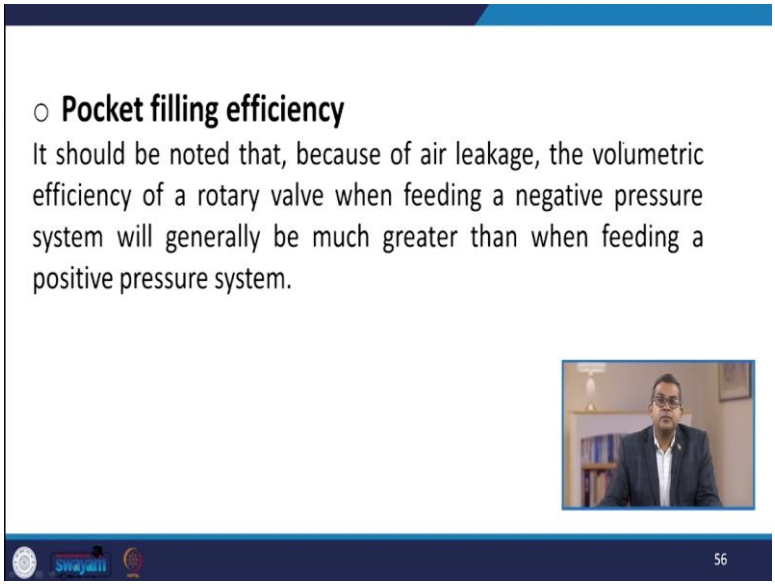

Let us talk about the pocket filling efficiency. It should be noted that because of air leakage the volumetric efficiency of rotary valve when feeding a negative pressure system this will generally be much greater than feeding a positive pressure system.

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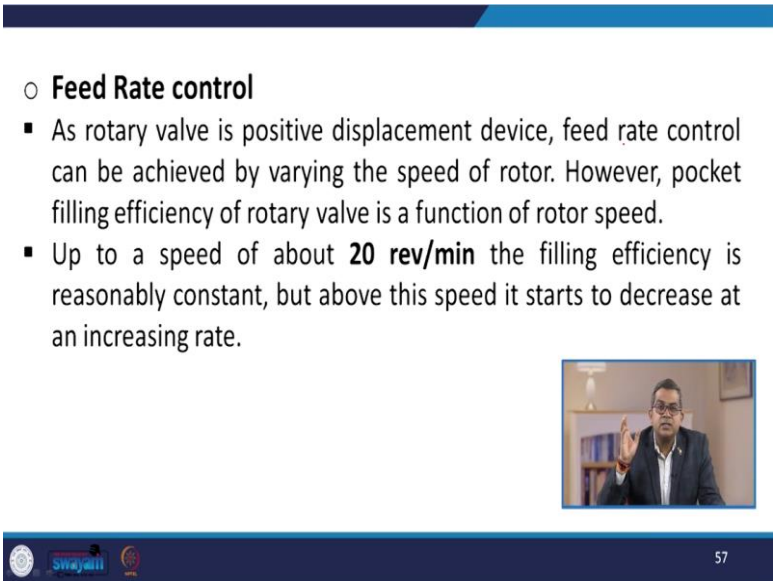

Let us talk about the feed rate control. As rotary valve is positive displacement device feed rate control can be achieved by varying the speed of rotor. However, pocket filling efficiency of rotary valve is function of rotor speed. So, up to a speed of about 20 revolutions per minute the filling efficiency is reasonably constant, but above this speed it starts to decrease at an increasing rate.

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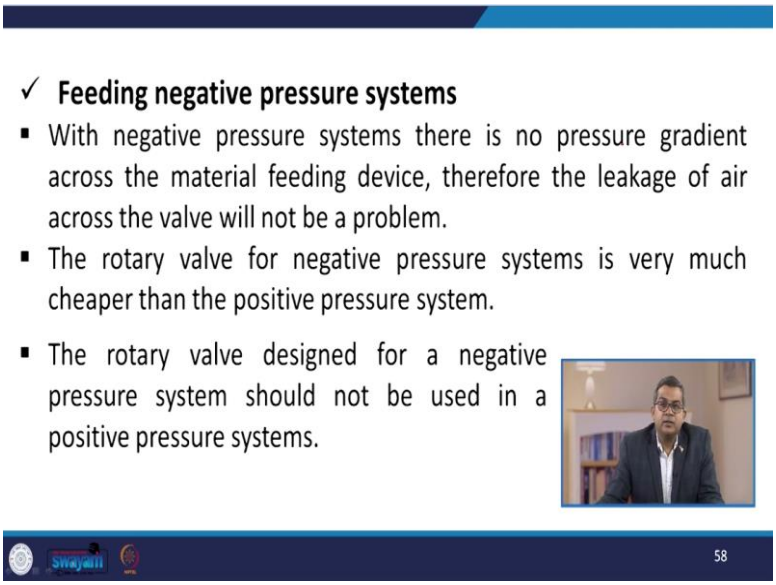

Now feeding negative pressure system with the negative pressure system there is no pressure gradient across the material feeding device. Therefore, the leakage of air across the valve will not pose any problem. The rotary valve for negative pressure system is very much cheaper than the positive pressure system. The rotary valve designed for a negative pressure system should not be used in a positive pressure system.

And that is the limitation of this particular type of system. So, in this particular lecture we discussed about various type of criteria for material as well as the selection of appropriate medium for different type of conveying system. For your convenience we have enlisted various references. You can go through these references as per your requirement. Thank you very much.