Oil Hydraulics and Pneumatics

Prof. Somashekhar S
Department of Mechanical Engineering
Indian Institute of Technology, Madras

Part 1; Energy Loss and Cost Break Down in Air Preparation Process, Pressure Drop and its Effect
Lecture - 27
Pneumatic Pressure Drop

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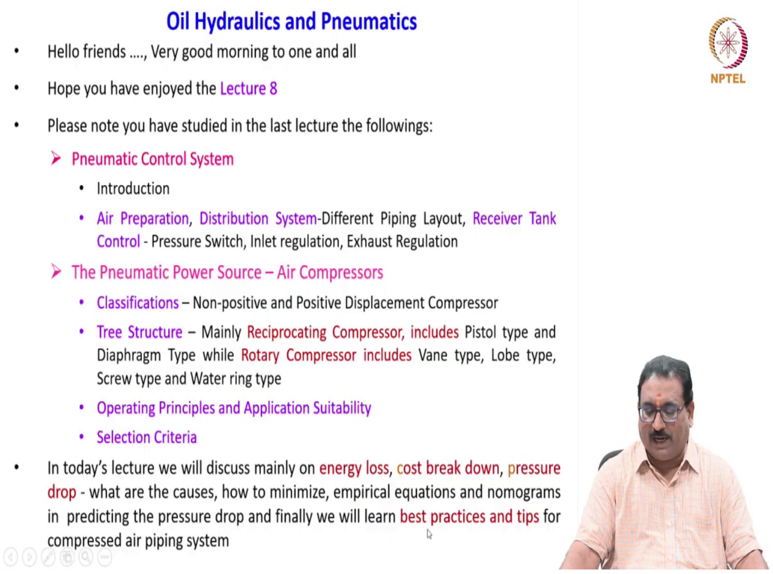

My name is Somashekhar, course faculty for this course. Hello friends, very good morning to one and all. Hope you have enjoyed the lecture 8. Please note, you have studied in the last lecture the followings; Pneumatic control system, introduction, air preparation, distribution system, different piping layouts, receiver tank control using pressure switch, inlet regulation and exhaust regulation.

We studied the air compressor which are the power source of pneumatic system in which the main classifications include non-positive and a positive displacement compressors. Then also, we discussed in detail the tree structure mainly the reciprocating compressors, include piston type and diaphragm type.

While reciprocating compressors include vane type, lobe type, screw type and a water ring type. Operating principles and application suitability of these compressors, we discussed in the last class and also, the selection criteria's. In today's lecture, we will discuss mainly on energy loss, cost break down, pressure drop, what are the causes, how to minimize the pressure drop, empirical equation and nomograms used in predicting the pressure drop. And finally, we will learn the best practices and tips for compressed air piping system.

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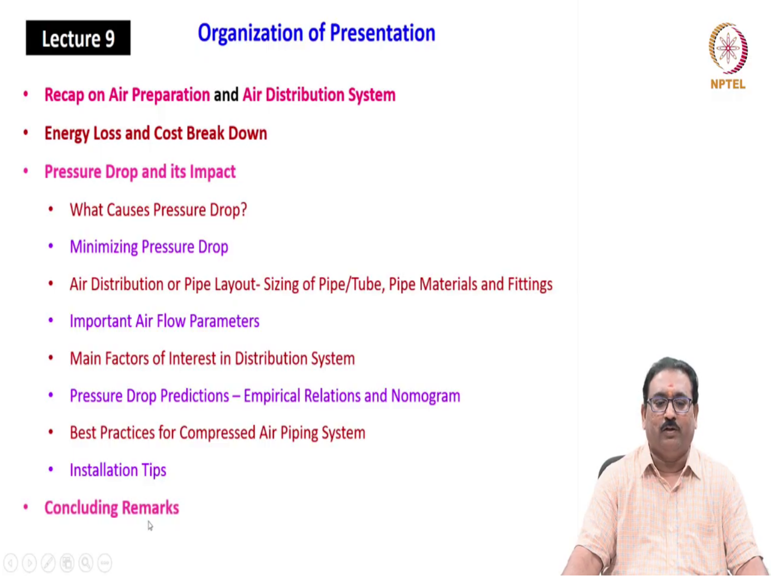

We will move on to the today's lecture organization of presentation. Let us very quickly I will recap on air preparation and air distribution system which is an input to this lecture.

Energy loss and cost breakdown, pressure drop and its impact; here, we will discuss what causes the pressure drop; how to minimize the pressure drop; air distribution or a pipe layout, basically, sizing of the pipe and tube, pipe materials and fittings; important airflow parameters; main factors of interest in distribution system; then, pressure drop predictions using empirical relations and nomogram; best practices for compressed air piping system; installation tips and finally, I will conclude today's lecture.

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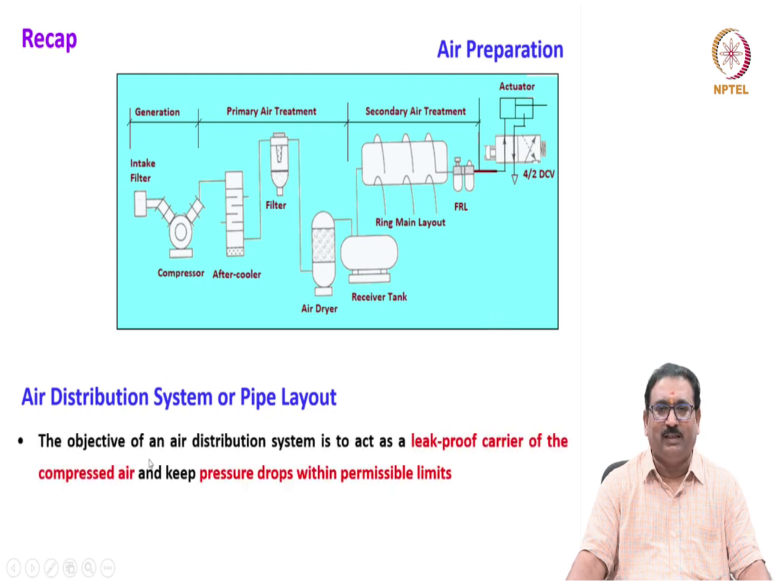

Let us we will recap what we have studied in the last lecture. We have seen the air preparation is one of the prime requirement in the pneumatic control system. We know that it includes the generation, then primary air treatment, secondary air treatment, then air will go to the actuator through the various valves; correct? Generation, we are using the compressor.

The duty of compressor is to sucks the air from the atmosphere, through the intake filters and compresses the air to the required pressure and then, transfer to the next of the system process. What you will call? The primary air treatment. What is the primary air treatment? As we know the exit air compressed air from the compressor is a very hot, again it contains the particles, foreign particles which are not able to remove from the intake filters.

So, the hot air should be cooled using the after coolers and also, filters out and then, during the cooling stage moisture content, moisture vapours will enters through the air. Then, we require the air dryers. Then, it will go to the receiver tank; the receiver tank contains the required quantity of air with required pressure.

There is always a link between the receiver tank and the motor or this compressors. Because you should not run the compressor continuously. It leads to various losses. Today, we will discuss what are these. Then, once it is stored the air, it should be distributed to the pneumatic machine tools or air tools. How it is? Using the ring main layouts..

Before going to the valves or any machine tools, air should be again filtered, regulated and lubricated using the secondary air treatment device what is known as FRL. Then, it will go to the valves and then, actuators. This is a very lengthy process of air preparations which will consumes a lot of money.

And also, remember friends, the air is passing from the compressor to the distribution point; correct? Various points, we are using the various pipelines, joints, links; correct? Many things we are using, tubing’s the wherever the connectors are there, there is a lot of losses are incurred during the process.

Today’s lecture, concentrate on the all these aspects. Also, we have seen the air distribution system or a piping layout playing a major role in reducing the pressure drops and losses. What is this? The objective of the air distribution system is to act as a leak proof carrier of the compressed air and keep pressure drop within the permissible limits.

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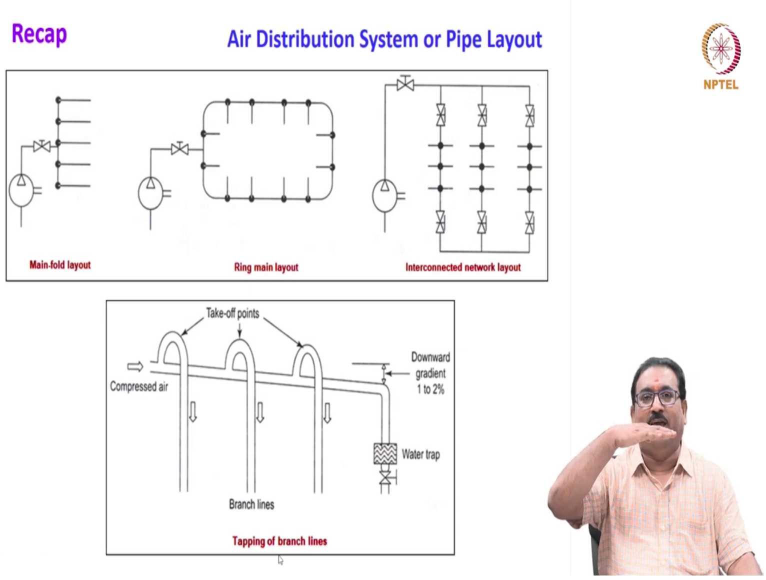

We have seen in the last class, the different types of piping layout. The main fold layout from the compressor distributes and ring main layer more popular used in many industries. These are all the tapping points, tapping to the various machines and power tools to drive it. Here is the interconnected network layout, various branches; each branch is equipped with the on-off valves and these are the tapping points.

Then, also the we have seen in the last class, you should not transport the compressed air in the straight-line pipes. Always it is inclined. Then, air is tapped from the top that is why it is a tapping point, you will see the tapping points from the top and it will go to the branch lines.

Then, water or air will flow here, then what whatever the water is contained here, it will take it out through the water traps. That is why always downward gradient of the pipes, main pipes 1 to 2 percent.

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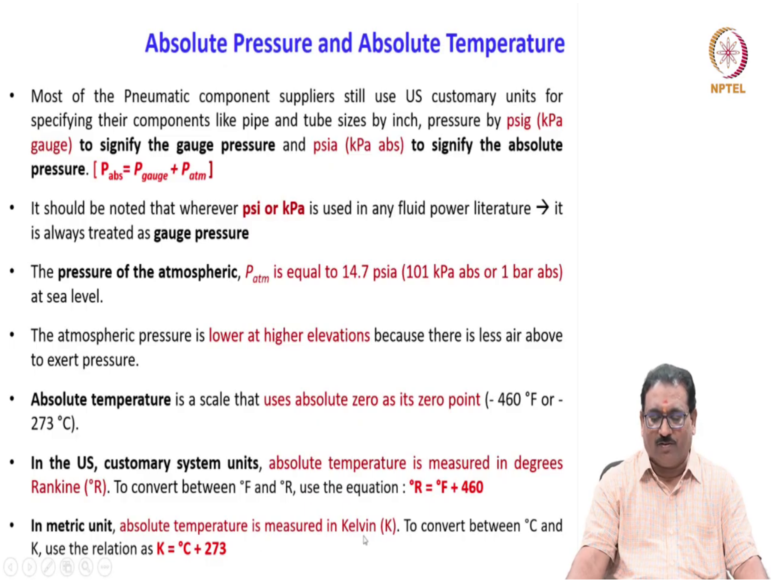

We have seen all these things in the last class. Very quickly going to the pressure drop calculations, these are some of the important parameters required is absolute pressure and absolute temperature. You have studied these things in many places like in thermodynamics, fluid mechanics and many other course.

Quickly, I will tell you. Most of the pneumatic component suppliers still use a US customer units for specifying the components like a pipe and tube sizes by inch, pressure by psig in psi unit kPa kilo Pascal to signify the gauge pressure; psia, meaning it is pounds per square inch absolute. Here, pounds per square inch gauge. Correct? In psi unit kPa abs to signify the absolute pressure. Absolute pressure, we know that P abs is equal to P gauge plus P atmosphere. it should be noted that, what wherever you are seeing the psia or kPa is used in any fluid literatures. It is always treated as the gauge pressure.

Some books, they will not write psig, they will write psia. It is understood that all are the gauge pressures. The pressure of the atmospheric air is equal to 14.7 psia or 101 kPa abs or 1 bar abs at a sea level. The atmospheric pressure is lower at higher elevation because there is less air about to exert a pressure. Atmospheric temperature is a scale that uses the absolute zero as its zero point, that is a minus 460 degree Fahrenheit or 273 degree Centigrade.

In the US, the customary system, absolute temperature is measured in degrees Rankine. To convert between the Fahrenheit and degree Rankine, use the relations R equal to F plus 460.

In metric unit, the absolute temperature is measured in Kelvin. To convert between the degrees Centigrade and a Kelvin, use the relation K equal to C plus 273. Knowing this absolute pressure and absolute temperature, we will move on to the energy loss and a cost break down. What is this?

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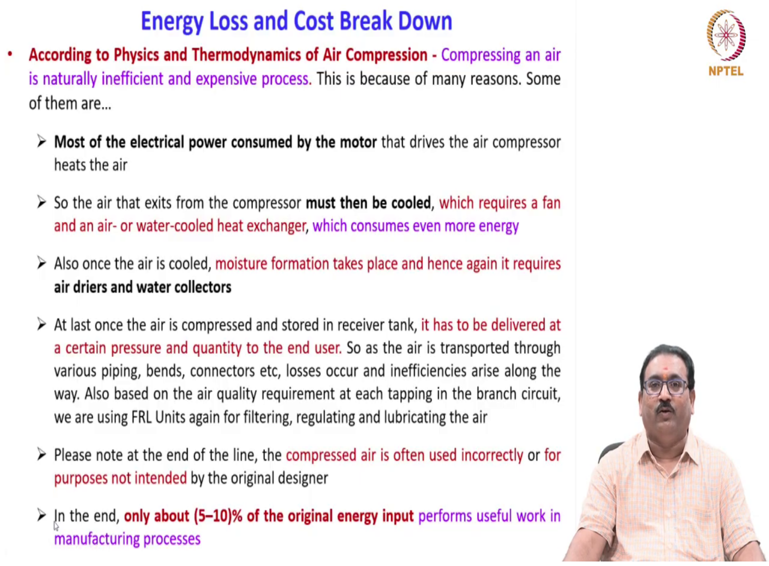

Energy loss and a cost break down from the generation to the point of use of the compressed air. What happens? According to physics and thermodynamics of air compression, compressing an air is naturally inefficient and expensive process. This is because of many reasons. Some of them are most of the electrical power consumed by the motor that drives the air compressor heats the air.

So, the air that exists from the compressor must then be cooled which requires a fan and an air or water-cooled heat exchangers, which consumes even more energy. Also, once the air is cooled, moisture formation takes place and hence, again it requires air dryers and water collectors. At last, once the air is compressed and stored in the receiver tank, it has to be delivered at a certain pressure and a quantity to the end user.

So, as the air is transported through the various piping bends, connector etcetera losses occurs and inefficiencies arise along the way. Also based on the air quality requirement, at the each starting in the branch circuit, we are using the FRL units again for filtering regulating and lubricating the air.

Please note at the end of the line, the compressed air is often used incorrectly or for purposes not intended by the original designer. In the end only about 5 to 10 percent of the original energy input performs the useful work in the manufacturing process. Then, question arises; where are the losses incurred during the air preparation to the end of the use of the this compressed air?

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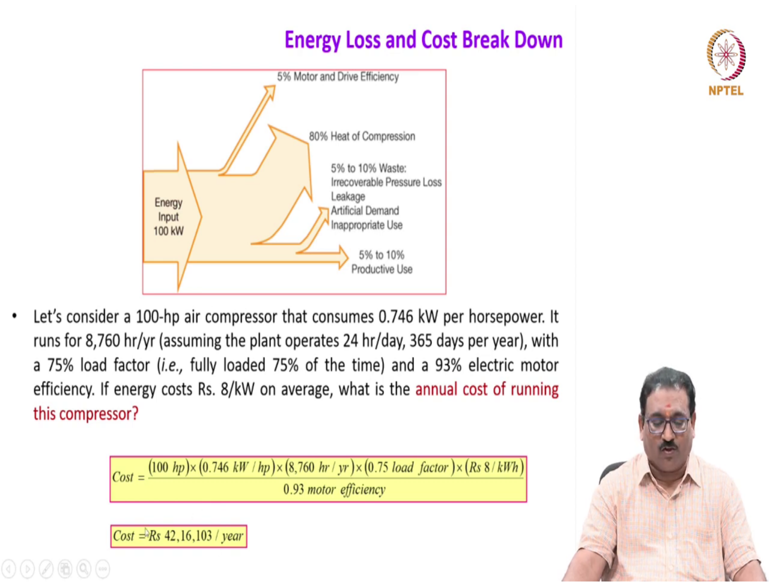

Then, you see here friends, the input energy input 100 kilo Watt is used most of this energy is used to heat the air; 80 percent for heat of compression; 5 percent motor and drive efficiencies; 5 to 10 percent waste that is irrecoverable pressure loss, also leakage, artificial demand, inappropriate use; 5 to 10 percent only use. For example, let us consider a 100-hp air compressor that consumes 0.764 kilo Watt per horsepower.

It runs for 8,760 hours per year. This is assuming the plant operates 24 hours per day and 365 days per day, assuming this and getting this these many hours with a 75 percent load factor. What is this? Full loaded at 75 percent of the time and 93 percent electric power efficient. If energy costs rupees 8 per kilo Watt on average, what is the annual cost of running this compressor?.

Knowing these parameter we will calculate what is the cost incurred. Here, 100 hp motor. How much power we are using and then, how many hours we are running the compressor; then what is the load factor; how much how much percentage we are using the compressor; then what is the cost per kilo Watt and motor efficiency? We will get here rupees 42,16,103 per year. See friends, how much cost we are using to compress the air electricity, how much we are using.

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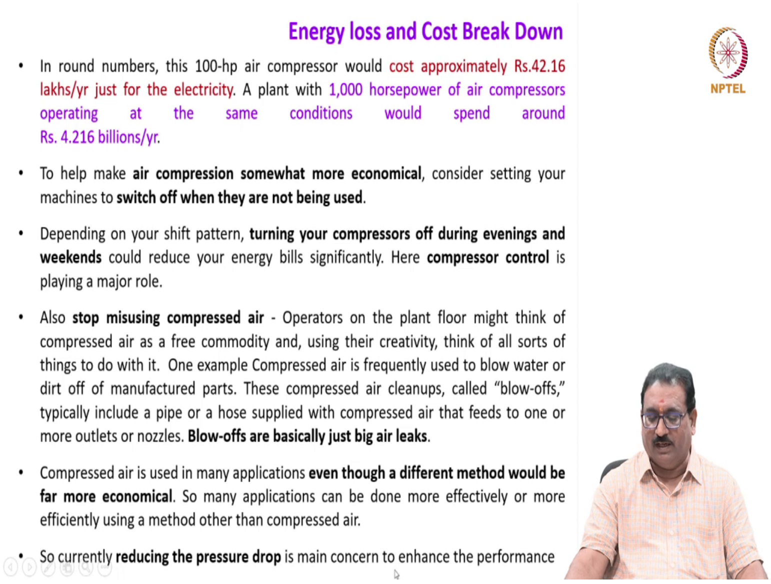

In round numbers, this 100-hp air compressor would cost approximately rupees 42.16 lakhs per year just for the electricity. If you assume a plant with 1,000 horsepower of air compressor operating at the same condition would spend around see the billions of rupees per year. To help make air compression somewhat more economical, consider setting your machine to switch off when they are not being used.

Depending on your shift pattern, turning to a compressor off during evening and weekends could reduce your energy bills significantly. Here compressor control is playing a major role. That is why I told you, there are three important methods to control the compressor; using the pressure switch or inlet regulation, exert regulation you have to do. As and when required, you run the compressor to store the air at required pressure and required quantity in the receiver tank.

Once it is stored, you have to switch off automatically. Also, stop misusing the compressed air. Operators on the plant floor might think of compressed air as a free commodity and, using their creativity, think all sort of things to do with compressed air.. One example, compressed air is frequently used to blow water or dirt off of manufactured parts.

These compressed air clean-ups, called “blow-offs”, typically include a pipe or hose supplied with compressed air that feeds to one or more outlet or nozzles. These Blow-offs are typically just big air leaks. If air will leaks pressure drops will take place.. Compressed air is used in many application even though a different method would be far more economical.

So, many application can be done more effectively or efficiently using a method other than the compressed air. But people are do not know the significance of compressed air. They will do a lot of misuse of this compressed air. So, currently, reducing the pressure drop is a main concern to enhance the performance.

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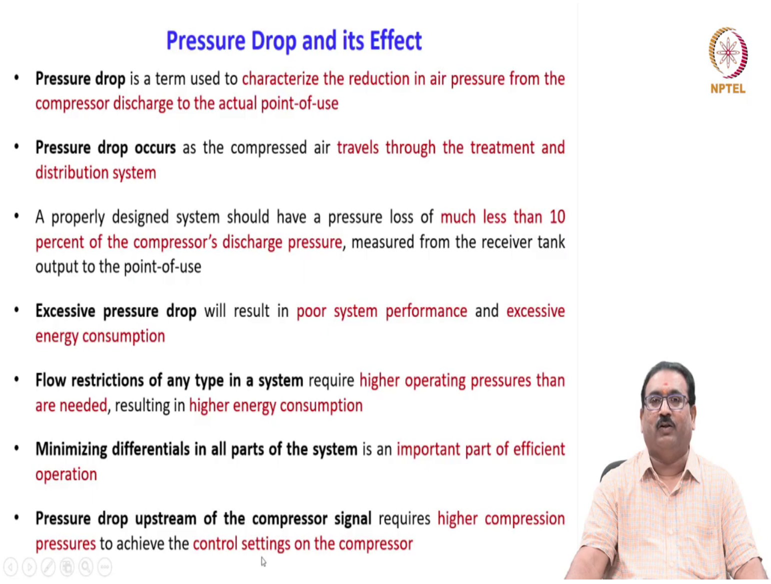

Now, let us we will see the pressure drop and its impact. The pressure drop is a term used to characterize the reduction in air pressure from the compressor discharge to the actual point-of-use. Pressure drop occurs as the compressed air travels through the treatment and distribution system.

A properly designed system should have a pressure loss of much less than 10 percent of the compressor's discharge pressure, measured from the receiver tank outlet to the point-of-use. Excessive pressure drop will result in poor system performance and excessive energy consumption.

Flow restrictions of any type in the system requires higher operating pressures than are needed, resulting in higher energy consumptions. Minimizing differentials in all parts of the system is an important part of efficient operation. Pressure drop upstream of the compressor signal requires higher compression pressures to achieve the control settings on the compressor.

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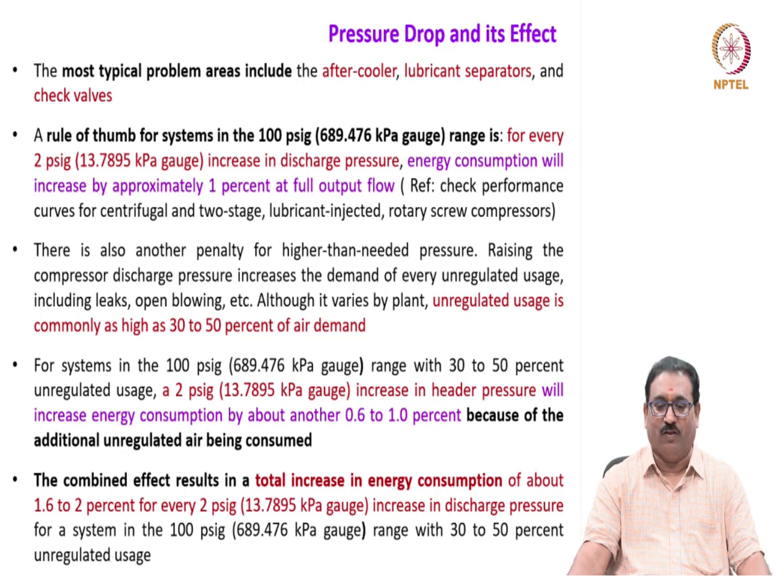

The most typical problem areas include the after-cooler, lubricants separator, and a check valves. A rule of thumb for a system in the 100 psig range if for every 2 psig increase in discharge pressure, energy consumption will increase by approximately 1 percent at full output flow.

There is also another penalty for higher-than-needed pressure. Raising the compressor discharge pressure increases the demand of every unregulated usage, including leaks, open blowing etcetera. Although, it varies by plant, unregulated usage is commonly as high as 30 to 50 percent of air demand..

For system in the 100 psig range with 30 to 50 percent unregulated usage, a 2 psig increasing header pressure will increase energy consumption by about another 0.6 to 1.0 percent because of the additional unregulated air being consumed.

So, the combined effect results in a total increase in energy consumption of about 1.6 to 2 percent for every 2 psig increasing discharge pressure for a system in the 100 psig range with 30 to 50 percent unregulated usage. See how much we are wasting the energy..

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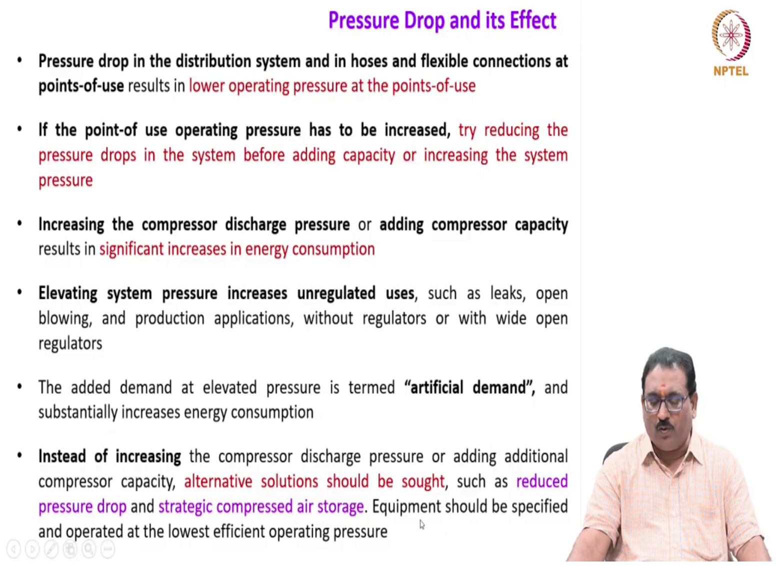

So, for pressure drop in the distribution system and in hoses and a flexible connections at a point-of-use results in lower operating pressure at the points-of-use. If the point of use operating pressure has to be increased, try reducing the pressure drops in the system before adding capacity or increasing the system pressure.

Increasing the compressor discharge pressure or adding a compressor capacity results in what happens here significant increase in energy consumption, that is why do not do this.. Elevating system pressure increases unregulated users such as leaks, open blowing, and a production applications, without regulators or with wide open regulators. The added demand at a elevated pressure is termed as "artificial demand", and substantially increases energy consumption.

Instead of increasing the compressor discharge pressure or adding the additional compressor capacity, alternative solutions should be sought such as reduced pressure drop and strategic compressed air storage. Also, equipment should be specified and operated at the lowest efficient operating pressure.