Manufacturing of turbines (gas, steam, hydro and wind)

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Lecture 02

Welcome to this lesson 2, in the course of manufacturing of turbines. So, in this lesson we will understand what is the need of turbines in modern energy systems. So, the outline of today's lesson will be as follows. We will be deep into the need of turbines by understanding the role of turbines in modern energy systems. Then we will look at how turbines help in efficient energy conversion, how the turbines used in renewable energy sectors can be integrated well with the grid, how turbines address the rising energy needs, how they provide environmental advantages, what is the sectoral versatility of these turbines. What are the technological advantages, advancements in economic contributions and future prospects of these turbines?

So, as we have discussed in the previous lecture that turbines are basically rotating mechanical components which generate power by converting useful work into electricity when they are coupled with a generator. So, these turbines as we have studied earlier, so they are primarily used in energy generation and based on the working fluid we have seen that popularly we have gas turbines, then we have the steam turbines. Then we also looked at hydro turbines and wind turbines. So in the scope of this course we are going to study the manufacturing of these turbines.

So in the previous lecture we have also seen that these turbines they use different types of working fluid like gas turbines use hot gases, steam turbine they use superheated or ultra superheated steam. Similarly, hydro turbines they use water and wind turbines they extract energy from kinetic energy of blowing wind. So, in modern energy systems, the turbines - they play a very crucial role especially not only in energy generation. but lot of other aspects also. So, we will start with one by one.

So, with gas turbine they are primarily used for power generation, wherein the gas turbines may be used in combined cycle plants. or they can be used as stand alone plants and what they do is they basically burn natural gas and subsequently these byproducts of burning the natural gas that is hot gases they are to turn the blades on the rotor of the turbine So, not only in power generation gas turbines are also popular in aviation sector where they are used to propel the jet engines. So in jet engines of course instead of

natural gas we use aviation grade turbine fuel and there also the hot gases are produced and instead of being connected to a generator we have a nozzle thruster which creates thrust and because of which the jet engines and aeroplanes are propelled. Then in steam turbines, if you look at the steam turbines, so the steam turbines also play a crucial role in power plants. So mostly the power plants that utilize steam turbines they function with either they are using fossil fuels like coal.

So combustion of coal basically creates heat and then that heat is used to convert water into steam subsequently the steam is created and it is then converted into superheated or ultra superheated steam and then the steam is used as the working fluid in the steam turbines water gets converted into steam here. And steam turbines, they also are very useful in industrial sectors where they directly are utilized to run several industrial equipment like pumps, compressors, hydraulic systems. So, all these systems are widely used in any industry and steam turbines are used to drive these systems there. Then if you look at hydro turbines, so hydro turbines they are also used in power, hydropower plants. So, these hydropower plants they basically extract energy from kinetic energy of flowing water.

So, from the kinetic energy of the flowing water we are able to extract mechanical energy or rotational energy and then this energy is converted into electricity. And hydro turbines are also used in a other way in pumped storage. So, pumped storage it is a concept of energy storage wherein the pumps are initially used to basically pump water from a lower elevation to a higher elevation when there is excessive supply of energy. So this water is then stored at a higher elevation and whenever there is a need, so this pumped water which is stored at a higher elevation is then allowed to come back to the lower elevation and the potential energy in the water while it is stored at a higher elevation is converted into kinetic energy and again the hydro turbines can be used to extract energy from this flowing water. So pumped storage it is kind of a energy storage system and this energy storage system it provides not only reliable supply of electricity when there are fluctuations and they also help in stabilizing the grid.

And then lastly we have the wind turbines. Wind turbines they are also used primarily in wind power plants in which we know that using wind turbines the kinetic energy of the flowing wind is converted. So, here kinetic energy of the wind is converted into mechanical energy and again using the connected turbo generator we can convert the mechanical energy, rotational energy into electricity. So, wind power plants they are known to provide clean and sustainable power because only wind is used in generating the electricity and used as the working flow. So, now we will look at what are the key reasons of using turbines in modern energy systems.

So key reasons, there are some of the important reasons. First reason is basically the turbines, they are helpful in electricity. So all the electricity generation can take place and

turbines provide crucial role in extracting energy from various energy sources like hot gases, flowing water, wind or steam. And we know the electricity whatever is generated it is crucial for functioning of residential areas, commercial areas and industrial areas. So, all these sectors they are dependent on electricity.

Secondly, they provide the turbines, they provide energy. security and reliability. So, what I mean by this point is that they contribute, turbines largely contribute in stable and reliable energy supply. because this demand and supply it keeps on varying throughout the day across various seasons and so on. So, presence of these turbines in the modern energy systems it basically ensures that we have a stable and reliable energy supply which supports the grid with consistent power generation.

So, they contribute in stable and reliable energy supply. The next point what are the reasons why turbines are important is environment - environmental benefits. So, in environmental benefits turbines especially which are coupled with renewable sources of energy. So, renewable energy sources which include hydro or wind. So, these turbines they help in reducing greenhouse gas emissions.

They also are beneficial because they also minimize the environmental impact which is generated by other turbines like steam when using fossil fuels or gas turbines by minimizing the production of greenhouse gases. And lastly, the technological advancement. So, in technological advancement all the ongoing research and development efforts in turbines are focused to make them more efficient, reliable, cost-effective and they are also helping enhancing overall performance of the turbines.

So, with this understanding and background of need and reasons of using modern turbines, we move ahead to look at other roles of turbine in modern energy systems like high efficiency that we have already talked about where turbines they are useful in converting kinetic or thermal energy of various sources into mechanical and electrical energy with maximized output, so design is done in such a way that we are able to have maximum output. For example, we can look at this schematic of a wind turbine. cut section where we can look at the various components of the wind turbine where we have these blades. These are basically the blades which are made up of materials which are having high strength and less weight.

So, these blades they interact with the incoming wind and because these blades they have an aerofoil shape, so the incoming wind it basically helps in rotating these blades and these blades they may be rotating at say 10 to 20 rpm depending on the actual wind conditions, velocity and so on. And then inside the box behind the blade which is known as the nacelle, we have very important components placed here which include the gearbox and the generator. We also have a yaw drive in between which basically, tilts the wind turbine in appropriate direction of the incoming wind to a certain angle. And what

happens here, the presence of this gearbox is designed in such a way by using planetary gear system so that the output of the shaft rpm after the gearbox it goes up to say 1800 rpm or 1500 rpm. because we cannot generate electricity with rotational speed of 10 to 20 rpm because whatever electricity has to be generated it will be supplied to the grid and we know that in the grid the electricity is being supplied at a fixed frequency of say 50 hertz in case of India and some countries are also using 60 hertz.

So, we have to maintain this frequency of the grid. So, for that we have to have the appropriate rpm and this gearbox in between. using the planetary gear system it helps to achieve that. So, what we can observe here that advanced design of the say for example, the wind turbine blade, the gearbox and so on, it ensures that the turbines are well integrated with the modern energy systems. So, the modern turbines they are also designed to have maximum efficiency so that they can convert the maximum energy of the working fluid into kinetic energy of the working fluid into the useful mechanical or electrical energy.

And advanced design they are also ensuring that maximum energy is extracted from wind, steam or water making turbines a key component in our modern energy systems. So wind energy we have already talked about it. It is very essential for harnessing wind power making it as we know wind is a sustainable and inexhaustible energy source. Hydroelectric already we have seen some details which transform kinetic energy of flowing water into electricity and these two the wind and the hydroelectric they come in category of renewable energy as there is no greenhouse gas emission and they also provide very reliable source of energy in our modern grid. So, modern grid is fed by all these conventional turbines like steam or gas and renewable energy sources turbine like wind or hydroelectric.

So, turbines are also important to address rising energy needs. For example, the global energy supply and needs are keep on increasing day by day. And they are also important in ensuring growth for any nation or society by providing reliable and steady source of energy which is essential for sustainable economic and industrial growth. So if you look at the schematic shown here highlighting the needs of energy in various sectors, so now with utilization of electric vehicles and so on, more need of electricity is there. So therefore, it is important to understand the need of these turbines and understand how these turbines are manufactured.

And the turbines that we will be discussing in this course like the hydro turbine or the wind turbine, they are also important for minimizing the greenhouse gases as discussed for lower emissions. And they also facilitate clean energy production, lowering the carbon footprint, mitigating climate change in a larger sense. So, electricity generation using all these things and all this sectoral versatility I have already discussed, but again for the sake of completion of the information. So, aviation and marine propulsion they are

also dependent on the turbines like aircraft engine, marine vessels and industrial use steam turbines or gas turbines used to drive industrial machinery used in manufacturing and processing sectors. All this production of energy from the turbines is then connected to the grids which are also now converting to smart grid which enhance in energy management and distribution with integration as per need of the end user.

And energy storage system as we have discussed the pumped energy storage system is very useful, when there is excess supply of electricity and when there is a need to generate electricity the pumped storage can be used and such type of energy storage systems are modern technological innovations being used where turbines play a key role. So turbines they also play key role in job generation because manufacturing sector is one of the largest employers and with the advent of manufacturing of turbines there will be several jobs created not only for manufacturing of these turbines but installation, maintenance and research will also generate several jobs and there are efforts to basically reduce the overall energy production cost making energy more reliable for our consumers and businesses. So, the future prospects of this turbine manufacturing is towards sustainable energy where we want to transition towards sustainable and renewable sources of energy. There is innovation and research which is going on to further improve the efficiency and adaptability of these turbines. And we can look from this figure which shows use of renewables in a global status report where we can see there is an increased focus on wind and say solar there.

And in coming years, there will be more and more renewable power additions increasing day by day to basically have net zero scenarios or net zero greenhouse gas emission scenarios developed. So, in summary, I can just mention here that turbines, we can say turbines are indispensable indispensable in modern energy systems for converting mechanical work into electricity. Ensuring constant and reliable energy supply and also they help in promoting sustainable sustainable progress in society which is sectors of society. So, just to summarize what we have covered in this lecture is we have covered essentials, essential role of turbines. We have looked at the how turbines help in efficient energy generation.

We have also looked at how the turbines address rising energy needs and we have also looked at their sector versatility and we have looked how they help in technological innovation. So, all these main topics were covered and we have now understood what is the need of turbine. So, in the next lecture we will be covering more details about specification of the turbines that is gas turbines, hydro turbine and wind turbine and steam turbines. We will look at all general specification, what are the key components, applications, design considerations materials which are used.

We will also look at key design principles turbine what is a turbine blade market because for manufacturing we also need to have a market where the turbines will be sold and we

will look at what are the challenges and future directions in this manufacturing of turbines.

Thank you.