Energy Conservation and Waste Heat Recovery
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Lecture - 01
Introduction to waste heat recovery

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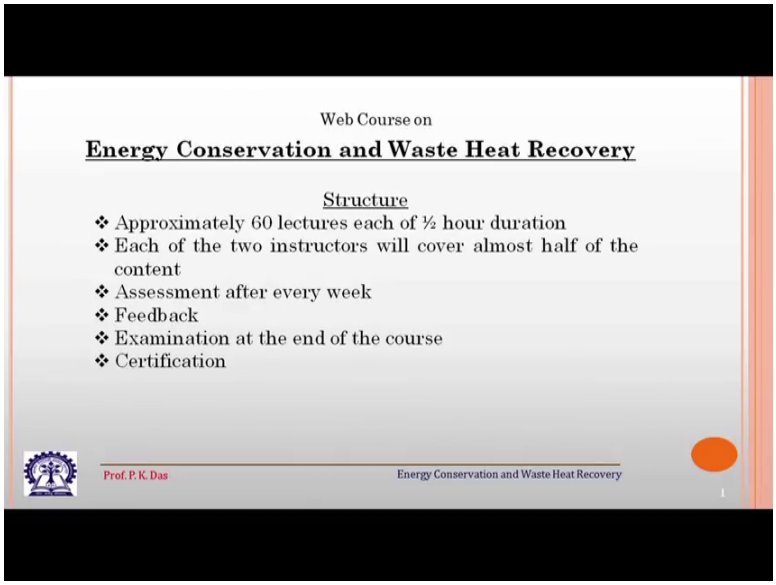

Hello everyone, welcome to the web course on energy conservation and waste heat recovery. Let me just give you the structure of the course approximately, there will be 60 lectures, each of the lectures will be half an hour duration, there will be 2 instructors and each one of us; we will be covering almost half of the content after every week, there will be some assessment and there will be some feedback also arrangement for feedback we can get queries from you; you will giving answer to those queries and at the end of the course there will be one examination and; obviously, there will be some certification.

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Well, if we see that as I have told, there are 2 instructors; I am Prasanta Kumar Das, I am attached with the department of mechanical engineering and along with me; another instructor will be Professor Anandaroop Bhattacharya from the same department and we had 2 teaching assistants, both of them are doctoral scholars, one is Mrinmoy Dhar and another is Sankalp Arpit; details of all the persons are giving here. So, that if you require any kind of assistance if there is any query confusion, etcetera, you may contact us particularly the teaching assistants will be of much help to you; time to time, they will coordinate; time to time means almost every week after one week course, they will coordinate the assessment and if you have any queries, etcetera you can directly contact them through their email.

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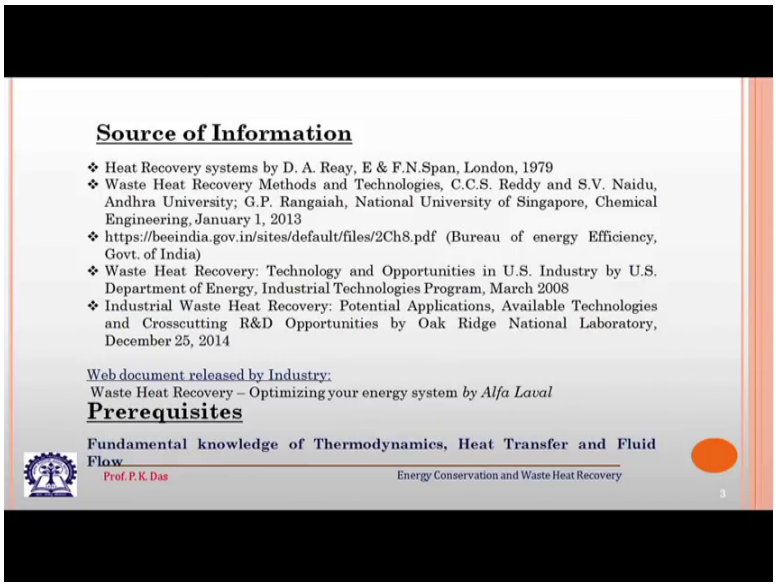

Then if we think of that; what is the source of information; obviously, our lectures will be there and you would covert to we would like to covert prefer to covert the aspects in such a way. So, that you need minimal amount of outside help, but within them some sources would be handy unfortunately there is no standard textbook on this particular topic which is multi disciplinary in nature and very very application oriented, but there is one book you can see the first reference which is bit old, this is heat recovery system by D A Reay, but there are many documents available in web, they are very helpful, the first one waste heat recovery methods and technologies, this is kind of paper which is a review paper published in a technological magazine called chemical engineering in 2 1013 quite recent.

Then by the government of India, bureau of energy efficiency there is very good document released and available in the web then waste heat recovery technologies and opportunities in us industry by us department of industrial technologies program, this is released in 2008, another document industrial waste heat recovery potential applications available technologies and crosscutting R and D opportunities, it is released by oak ridge national laboratory that is again of recent origin 2014, then many industries; they have released documents these are some extent buyers to their own product, but some of them are having quite a few generalize features like one of them, I have listed over here waste heat recovery optimizing your energy systems by Alfa Laval.

Every subject has got its prerequisites. So, this subject has also; it is prerequisites, this is some sort of application oriented subject as I have told, it is not a fundamental one, but it derives its strength, its basis from a few fundamental subjects fundamental knowledge of thermodynamics heat transfer and fluid flow is necessary, but that is at the fundamental or basic level and some of these we will recapitulate. Particularly, the thermodynamic aspects of different energy options energy activities we will recapitulate when we will proceed with this course.

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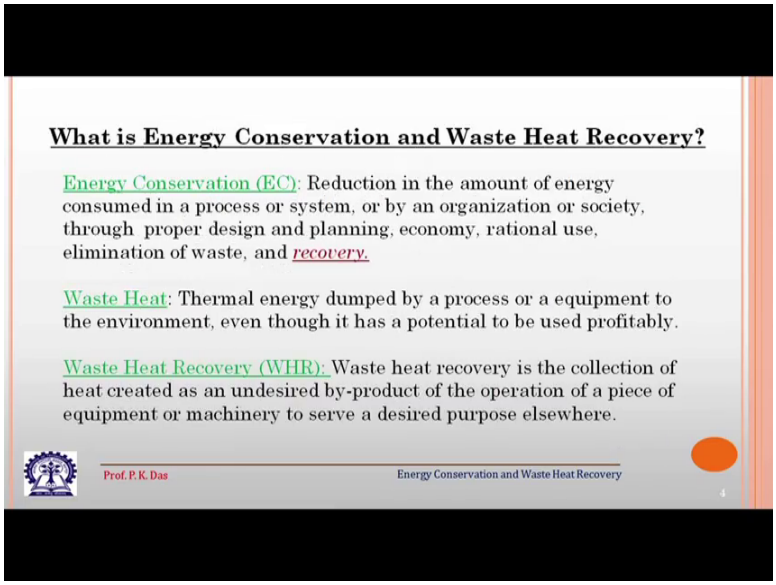

To begin with, let us know what is energy conservation and waste heat recovery some sort of a definition there could be many different definitions for this 2 topics, but some workable def definition let us have at the outside. So, that we can proceed with this course energy conservation that is that can be thought as the reduction in the amount of energy consumed in a process or system or by an organization or society through different activities what are these different activities these activities are proper design and planning economy; economy of energy use rational use of energy elimination of waste and recovery you see the last word recovery which basically means waste heat recovery to a greater ext to a great extent has been put in red color so; that means, we want to show that energy conservation is a much broader pro perspective and in that waste heat recovery or recovery is a part. So, if you consider that energy conservation is a very big set then waste recovery will be a sub set of it.

Now, let us see what is waste heat recovery; first what is waste heat thermal energy dumped by a process or a equipment to the environment even though it has a potential to be used profitably. So, that thermal energy is called waste heat. So, in industry we will find lot of examples where we are dumping the thermal energy to the environment because that is the demand of second law for deriving any kind of mechanical work useful work out of thermal energy because that is how one can exchange heat and ultimately cert certain amount of thermal energy has to be dumped to the environment. So, this is a mandate that certain amount of thermal energy has to be has to be dumped to the environment.

Now, while this dumping; dumping is essential. Now how much of it and at what temperature we are dumping the thermal energy that is a concept, but whatever may be the quantity or temperature at which we are dumping the thermal energy this energy is called waste heat now what is waste heat recovery waste heat recovery is the collection of heat created as an undesired by product of the operation of a piece of equipment of machinery to sub a desired purpose elsewhere.

So, let us take some example let us say you have bought your car or you have bought your 2 wheeler. So, there is an exhaust for the both the for both the car and the 2 wheeler because the internal combustion engine inside internal combustion engine, the fuel is undergoing a combustion process energy is released as thermal energy and then from their motive power is generated and the car or the 2 wheeler moves. So, the exhaust gas which comes out that will be at a considerably higher temperature compared to the environmental the condition of the environment or temperature of the environment. So, this is your waste heat.

Now, let us say the automobile is a big one we have got some sort of option for converting this waste heat which is otherwise dumped to the environment into some useful into some use let us say there are for big automobiles it could be possible to use this waste heat use this waste heat for cooling purpose employing some sort of absorption cycle. So, then this is your waste heat utilization. So, waste heat is kind of part and parcel of many of the industrial processes. So, the some amount of thermal energy has to be dumped to the atmosphere, but there are many options many opportunities where part of this thermal energy can be converted back and we can make some use out of it that is called waste heat recovery.

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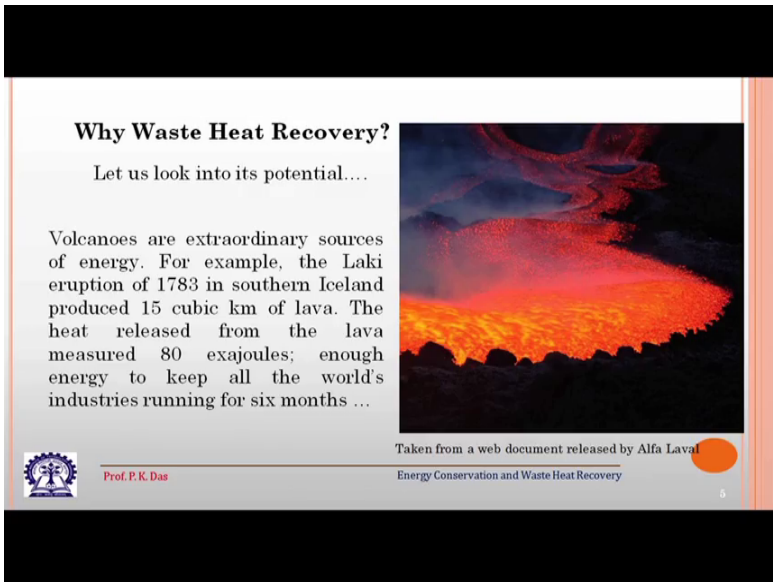

Now, then why waste heat recovery. So, let us look into the potential of waste heat recovery here in the in this picture there is a there is a photograph of volcanic eruption and flow of lava volcanoes are extraordinary sources of energy for example, this is examples from the past the Laki eruption of 1783 in Sothern Iceland produced 15 cubic kilometer of lava the heat released from the lave measured 80 exajoule; exajoule, what is exajoule 10 to the power eighteen joule is 1 exajoule enough energy to keep all the worlds industries running for 6 months, this; I have taken from the website or from the web document published by Alfa Laval.

So, you see ultimately what happened to this the huge amount of thermal energy which could have the run the industries of the entire world for 6 months. So, this got waste heat. So, this gives an example that how what could be the potential of thermal energy which we are wasting of course, these example have been taken not from industry from some sort of natural phenomena, but the industry also we will find examples where a good amount of it large amount of thermal energy is being waste heat quote un quote waste heat or dumped to the environment where it does not have any potential to do useful work and we try to recover this we try to recover this as a policy of energy conservation. So, probably it could be some sort acceleration to mention the growing concern for the energy crises; that means, we are depleting the fossil fuel which was available at a very faster rate as the civilization as the industrialization proceeds and at the same time we are also degrading our environment by the energy use.

So, waste heat recovery it is a very; it is a very efficient mean to have some sort of a slowdown in both this; that means, we can slow down the depletion rate of the available fossil fuel and we also can slow down the degradation of environment. So, that shows the importance of waste heat recovery which is one of the activities of the whole activity of energy conservation.

Now, in this course what would we would like to do we are going to give much stress on waste heat recovery, but waste heat recovery cannot be discussed in isolation with energy conservation and there are quite a few energy conservation principle which we will touch upon which we will go little bit deeper into while discussing waste heat recovery. So, that is why this course has been named as energy conservation and waste heat recovery, but here I just like to give some sort of a word of question that it does not cover all the aspects of energy conservation probably for waste heat recovery we have gone to the full depth, but for energy conservation we have touched upon a few selected topics which are much related important and much related to waste heat recovery.

Now, as we were proceeding with the potential of waste heat recovery let us see; what is the true potential of waste heat recovery; after getting this example from a natural calamity.

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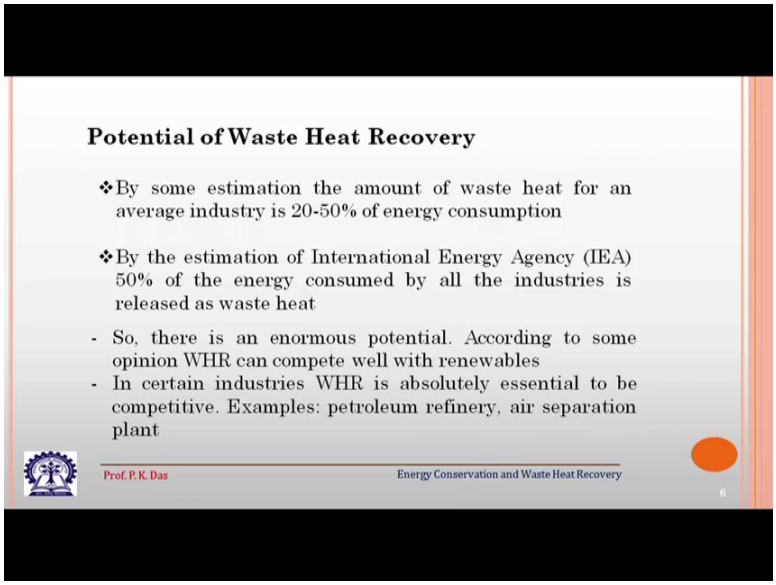

The potential of waste heat recovery by some estimation the amount of waste heat for an average industry is twenty to fifty percent of energy consumption. So, for running an

industry we need energy either it will be electricity supplied from the grid or electricity generated by captive power plant of the same industry or the industry will need fuel for different kind of process requirement. So, it has to burn fuel to generate hot air or hot water or steam. So, it needs energy there is energy consumption either in the form of electricity or in the form of thermal energy now waste heat recovery can reduce this energy consumption by 20 to for 50 percent to this is a huge amount.

Then by another estimation and this estimation is by international energy agency IEA fifty percent of the energy consumed by all the industries is released as waste heat. So, this has got 2 implication first implication is that how much energy we are quote unquote wasting and how much energy could be reused. So, it shows that potential and if 50 percent if the energy goes to the environment, then what is the implication this is almost as one can take as that whatever is wasted is a whatever wasted is a potential source of pollution so; obviously, when 50 percent of the energy which we are taking for using it for doing some work and it is wasted because we could not utilize it then; obviously, it is a potential source of pollution. So, even if some portion of it can be recovered then what we are getting we are cutting the fuel wheel and at the same time we are protecting the environment.

So, waste heat recovery we will come back to this point time and again it is repetition, but you see we repeat those things which are important. So, this is very important to understand that when we do this waste heat recovery any activity of waste heat recovery, it has got a 2 prompt approach, we save fuel, we save energy and at the same time, we save safeguard our environment.

So, from this 2 figures what we can see that there is an enormous potential for waste heat recovery according to some opinion waste heat recovery can compete well with renewables. So, this point needs certain this point need certain elaboration, see we are talking much about renewable as we have depleting the fossil fuels. Now when we talk about renewables again, there are a number of number of advantages first thing is that it is not I mean depleting we are; when we are using renewable like wind energy or solar energy or ocean energy we are not depleting it is available we are only taping it and using it and at the same time most of them are clean source of energy. So, that we are not degrading the environment.

Now if we see these 2 aspects of renewable energy understandably there is lot of stress for or lot of emphasis for using renewable energy there are lot of research activities there are lot of initiatives incentives from the government agencies and there are directives also there are legislations also mandates also for using renewable.

Now, here one can say that waste heat recovery though it is not renewable, but it can come as a alternate way and it can be as an equivalent of the renewables because it has also got 2 aspects very strong aspects it can save energy it can save costly fuel fossil fuel and at the same time it is reducing the degradation of the environment is there any other advantage yes there are some more advantages compared to renewable; what are those for renewables you have to have a new set up all together for hardness in renewable energy, but let us say you have got already you are having a factory or an industry where there is waste heat.

So, there is there is potential for recovering this waste heat and what you have to do your investment could be quite lesser compared to having the investment for renewables because in the existing set up itself you are trying to recover some of the waste heat and reuse it. So, in many cases we will find particularly for existing industries we will find that waste heat recovery can have a leverage over the renewables and in other cases, what it could be; both these thing can go hand in hand; one can have some sort of energy center where there will be fossil fuel there will renewable and there will be principles for waste heat recovery and with all these activities one can have a best option for utilizing energy in the best possible way degrading the environment the least amount.

In certain industries waste heat recovery is absolutely essential. So, that the industry can be competitive for years together those industries are using waste heat recovery in different form the examples are petroleum refinery. So, in petroleum refinery what we are going to what; what is our activity in petroleum refinery; we get different grades of oil by fractional distillation. So, fractional distillation needs heating and also its needs cooling.

Let us say if you do this heating and cooling separately, then there will be enormous demand of energy and the product which will roll out of a refinery will not at all be competitive in the market, but at the same time if waste heat recovery principle or in general energy conservation principles are followed and we try to see whether the

heating requirement and cooling requirement can be made mutually internally without taking any kind of or without taking less amount of least amount utility from outside so; obviously, we will have an energy efficient answer to this problem.

Then the same applies for air separation plant also and there are many examples where waste heat recovery is practiced for years together, but our point is that this is not enough and there are enough opportunity lot of opportunity exists for further exploitation of this principle of waste heat recovery sector where the potential for waste heat recovery exists.

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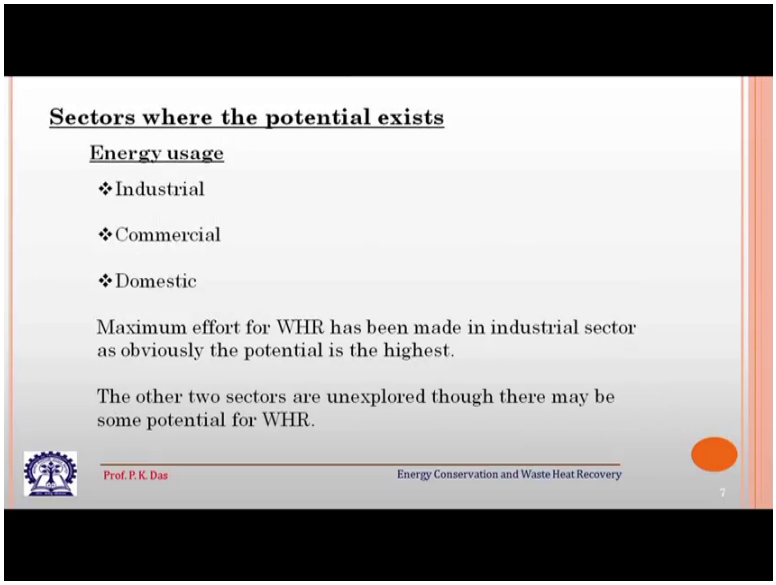

So, waste heat recovery is the recovery of energy in the form where energy is used in the thermal form and; obviously, this will come from the sectors where there is energy use energy usage there are different sectors three important sectors I have mentioned there could be many or some more.

One is industrial sector one is commercial sector, domestic sector, another important sector could be transportation the maximum effort of waste, heat recovery has been made in the industrial sector justify the because in the industrial sector we have maximum potential for waste heat recovery, but the other 2 sectors though unexplored, it can also produce some sort of energy saving through the principles of waste heat recovery particularly in the commercial sector and there are already some initiative to have waste heat recovery principles applied in commercial sector.

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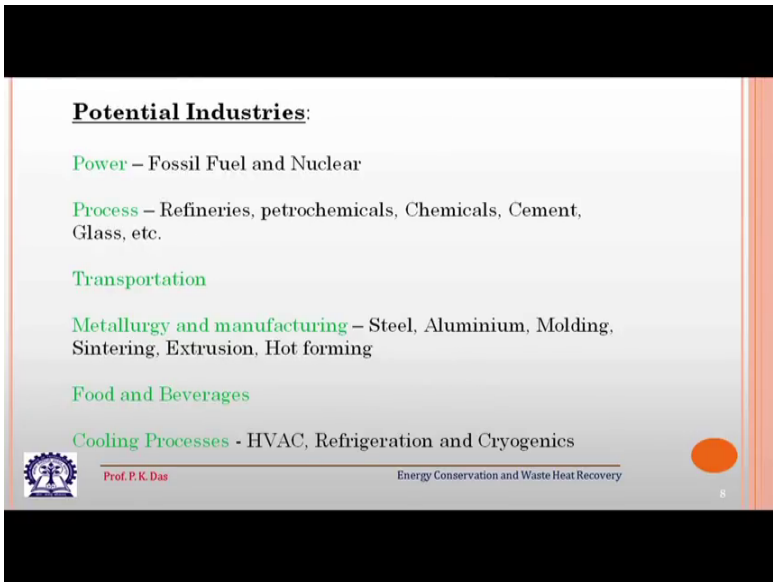

Let us see the potential industries power industry power industry we can. So, in power industry what we are doing in power industry basically electricity is generated electric power is generated and that route is thermal mechanical electrical that is the route that from some source, we are getting thermal energy that thermal energy is getting converted into mechanical energy and then this mechanical energy converted into electrical energy. So, the power energy that depends on fossil fuel nuclear fuel and; obviously, here there is lot of scope for waste heat recovery.

Then process industries already I have named refineries then there are petrochemicals chemicals cement glass etcetera transportation; transportation is a good sector where I mean, it is dependent on the movement of people and goods and at the same time it consumes lot of energy and there is a good scope of waste heat recovery, there are problems the problem is that transportation whenever there is any initiative for waste heat recovery; obviously, it may or it may increase the cost or the weight of the moving system and that may have detrimental effect on its efficiency on its competitiveness, but lot of potential exists for railway industries for cruisers big ships waste heat recovery could be a good principle for reducing the cost of operation for airliners there are energy principles and; obviously, in that waste heat recovery is also embedded that it can cut the fuel cost.

So, these are the possibilities in industries and then food and beverage industry and then cooling processes, heating ventilation and air conditioning, refrigeration, cryogenics, waste heat recovery has got a good scope in all these activities. With these, I like to stop for now. We will continue with these in our next lecture and we will see more of waste heat recovery in the coming lecture.

Thank you.