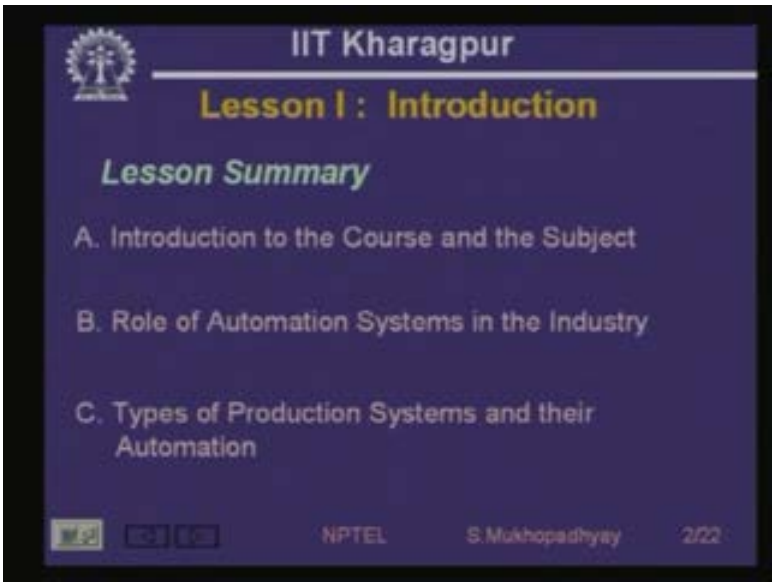
Industrial Automation and Control
Prof. S. Mukhopadhyay
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur

Lecture - 1
Introduction

(Refer Slide Time: 00:29)

Good morning, this is a course on industrial automation and control recorded under the NPTEL program at IIT Kharagpur. I am Siddhartha Mukhopadhyay of the department of electrical engineering at IIT Kharagpur. Today we are going to look at the content of lesson one. So, let me start my presentation, so this is a course on industrial automation and control.

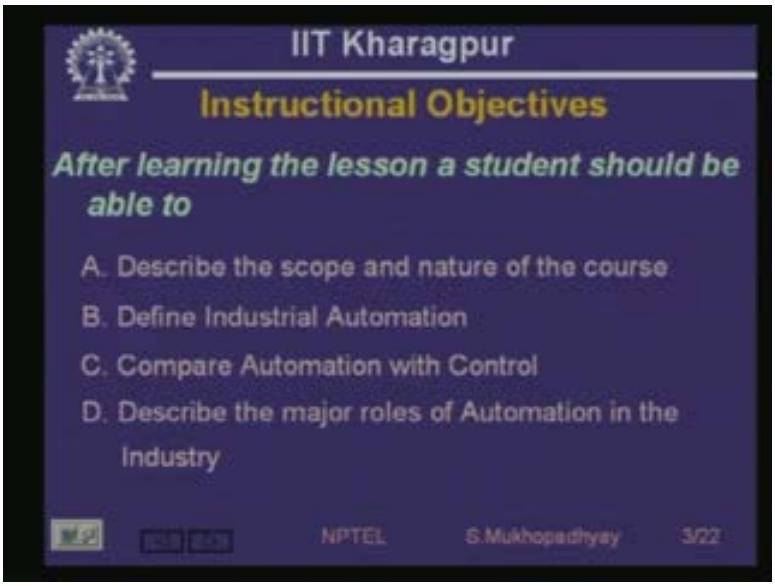
(Refer Slide Time: 01:32)



We are going to start with the first lesson, which is on introduction. Let us before we start on, let us look at the summary of the lesson. So, we are first of all we are going to have an introduction to the course and the subject having done that we shall examine the role of automation systems in the industry. What it does to a factory, why it is considered, so why it is found.

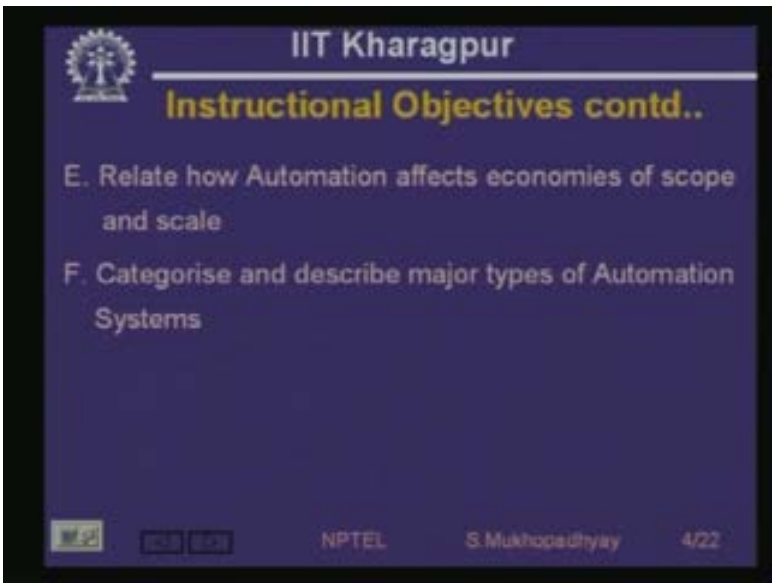
So, widely existing in all types of factories, how it can generate money and then we will look at the various types of factories and the various types of automation systems, which are suitable to these respective types of factories. So, that is what we are going to do in this lesson a broadly speaking before we start of first of all we need to understand the instructional objectives. That is what is it there student is expected to be able to do after going through this lesson.

(Refer Slide Time: 02:55)



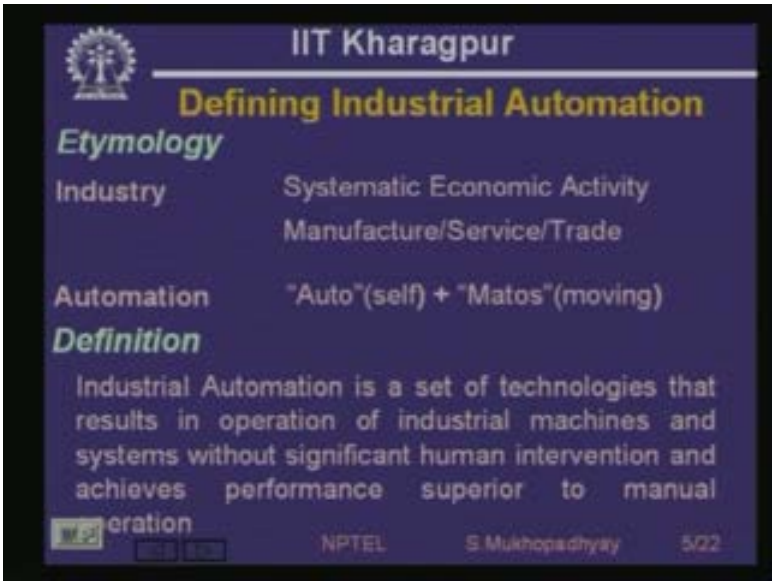
So, after the lesson a student should be able to describe the scope and nature of the course. There you know given understanding of what he can expect from this course what type of course it is, what kind of an exposure he is expected to get. He will be able to define industrial automation, what it is he will be able to compare automation with control this course has two terms industrial automation and industrial control. So, he will be able to understand what are the similarities and differences between these two terms. He will be able to describe the major roles that automation plays in the industry.

(Refer Slide Time: 04:01)



He will be able to relate two terms called economies of scope and economies of scale and I will see how automation enhances these. He will be able to he will be able to categorize different types of industries and describe the major types automation which are suitable for each kind. Finally, he will be should be able to provide industrial examples to illustrate these above points. So, this is what a student is expected to do after going through this lesson. Now, before we actually plunge into the lesson, let us first of all define industrial automation and my experience says that a very good way of defining anything is to go to a good dictionary and try to find out the meanings of the words which constitute the term.

(Refer Slide Time: 05:11)



So, let us look at the etymology of the name Industrial Automation. So, what does industry mean in a broad sense an industry is nothing, but a systematic economic activity. Now, economic activity means what economic activity may be related to manufacture, it may be related to service or it may be related to trades. In this course, we are primarily concerned with manufacture. So, we will essentially be talking about the manufacturing industries.

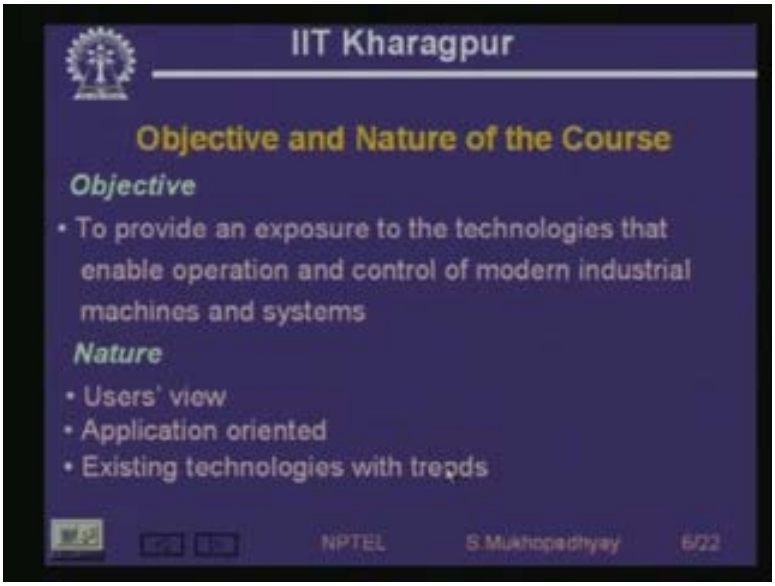
Next, what is the meaning of the term automation, the term automation is actually derived from two Greek words one is called auto which means self, another means another is the word matos or moving. So, together and automation is a device or an object which moves by itself. So, now this is the essence of the word automation and

from this you can very easily understand and the definition of automation which I have point.

So, the definition of automation says as I read is that industrial automation is a set of technologies that results in operation of industrial machines. Systems without significant human intervention number one that is the meaning, which is embedded in the term self moving. So, it does not require too much operator intervention and more than that it achieves performance which is superior to manual operation.

So, an automated machine cannot get bored, it cannot make mistakes due to fatigue it does what it is expected to do each time with the same quality. Of course, it can also handle things, which are much larger, which are not possible to do with human operators. So, in these senses it can achieve performance which is superior to manual operation, so this is a definition of the word automation which I have point.

(Refer Slide Time: 08:19)



Now, let us look at the objective and the nature of the course. The basic objective of this course is to provide the student with an exposure to the technologies that enable operation and control of modern industrial machines and systems. In other words if you go to a factory you are very likely to encounter a set of machines. For example, you are very likely to encounter sensors you are very likely to encounter controllers you are very likely to encounter actuators then communication systems man machine interfaces.

So, the idea is that a student would know at least something about these would be familiar to an extent about these technologies which typically exist in an industrial facility. Keeping this is mind the nature of the course is firstly essentially we want to provide a user's view. Whenever you are discussing a technology you can either take users view to provide an exposure to basically an understanding of how things work. May be some amount of integration how things can be put together and some and basically aspects of operation.

So, that is the view that we are going to take here contrasted to this there could be a view of the designer that is how to design and make those machines. Now, that is and that is that is an order of magnitude more complex a task and in this course. We are going to attempt that we are also most of the time, we are going to be very focused on an application. So, when we discuss control we are not going to talk about abstract transfer function, which we call plants rather than that we are we are going to talk about to transfer functions, but we will always make it explicit.

What this transfer function stands for, what is the physical object, why is it used? So, the actual application context will always accompany all our discussions. Secondly, we are not going to we are mainly going to give a basic understanding of the existing technologies that itself is quite huge of course, we are sometimes going to discuss some trends. We are going to discuss some trends, but we are not going to deal too much into the trends or too much into research.

Finally, we are going to embark on a discussion which is essentially interdisciplinary. So, it is not going to be discussion only related to electrical engineering, but will involve various aspects of chemical engineering mechanical engineering and computer science and engineering. So, this is what can be expected from this course having clarified that, let us first take a reasonable look on the role of automation industry.

(Refer Slide Time: 11:51)

This is very important to understand because this is the only lecture, where we will discuss the kind of technology that we are going to discuss for the next several lessons. How this technologies actually produce an effect, which is considered a tremendous advantage from the point of view of economy. So, let us first try to understand since automation is for the factory let us first try to see what basically a factory does.

So, a factory essentially a factory essentially starts with raw or unfinished material, it could be either raw material for example, in an iron and steel factory. You start with iron one, that is your raw material and you produce a finished product which in this case is steel. On the other hand, it could also start with some unfinished material which is when you build a car, you actually buy lots of parts from which are which are manufactured in other factories and you put them together to build the car.

So, you could either start from a raw material or you could start from some unfinished material and then finally, land up on a finished products, this is the essential function of any factory. How does it do that for doing that it requires it requires several things. For example, it requires energy it requires manpower and it requires infrastructure of various kinds it requires land, it requires equipment it requires water power etcetera.

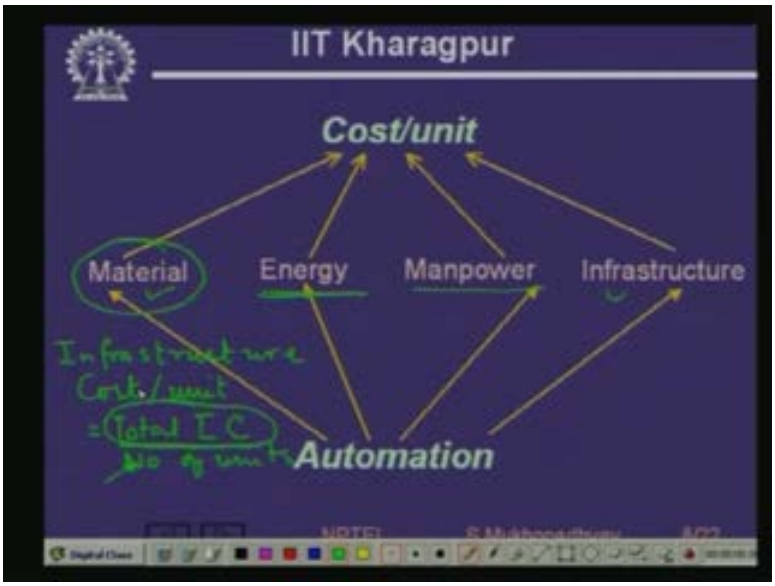
So, all these I have categorize into three different types, one is energy another is manpower, another is infrastructure and using these and through a manufacturing process the raw or unfinished material is transform to finished product, so this is the basic

function of a factory. What is the basic goal of a factory, what is the basic economic goal? It is a systematic economic activity the basic goal is, obviously to make profits. Now, we have to understand what effects profit and we will see that automation affects almost every aspects of profit making that is why, it is so crucial for the success of an industry.

So, to make that point let us define a very simple equation, which says that profit is price per unit minus cost per unit into production volume. Here, we are assuming that whatever you produce you can sell. So, over a given time the profit you will get assuming that you can sell it assuming that you can sell whatever you produces, this is going to be the profit. So, from this equation which is very simple, you can easily understand what will increase profit for example, if you can bring down cost your profit will increase.

Similarly, if you can increase the production volume assuming that the market is large enough. So, that you can sell them then also your profit will increase and at the same time, if you can sell a given product at a higher price then also your profit will increase. So, now let us see that how automation can bring down cost can increase production volume and sometimes can increase price, so let us look at cost per unit.

(Refer Slide Time: 16:56)



So, cost per unit is effected what it can be broken up into several components, the overall cost of producing one unit of the product can be broken up into several components.

What are these components? The first one is material cost, so obviously the material cost is a significant part of the total cost. Then, there is energy cost this is becoming more and more expensive energy is becoming more and more expensive not only because of the energy cost because of other cost which are associated with energy for example, that is prevention of pollution. That is the cost of producing clean energy and because of policies today state polices that cost is becoming more and more.

Then of course, manpower costs, if you are going to employ a people you will have to manage them, you will have to make a set up all these are going to be expensive. There is also infrastructure cost that is the cost of acquiring land the cost of acquiring equipment. Remember that while material energy and manpower cost are sometimes called variable costs because their cost which we have to make their, which we have to incur on a recurring basis, while infrastructure cost is generally onetime costs.

You know they are called sometimes they are called fixed cost. So, obviously the infrastructure cost if you try to find that per unit cost what component goes to the infrastructure. Then the total fixed cost must be divided by the number of units that you have produced while that infrastructure was used. So, now, let us see how automation can really affect them.

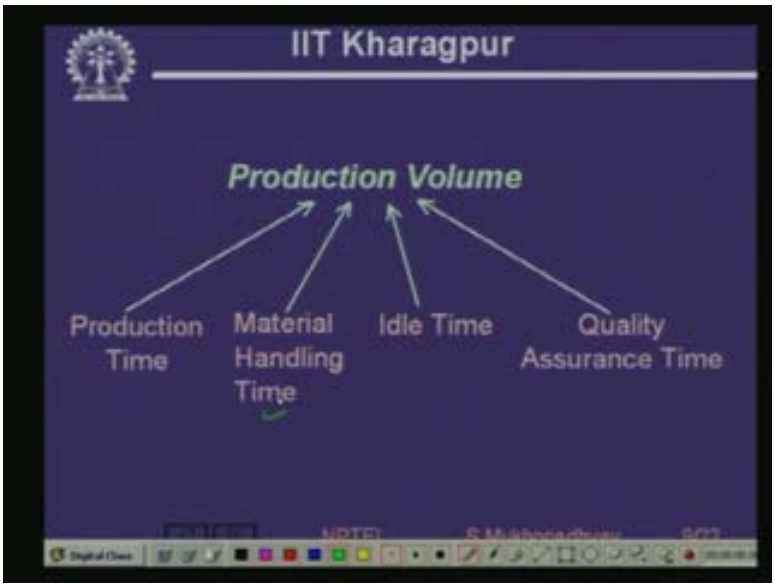
So, automation can reduce material cost various examples are there for example, suppose you have a sheet metal industry. So, you want to cut say several pieces from a from a large sheet, if you have an automated machine and if you have programmed it cleverly then the amount of scrap that you generate is going to be much less. You have better quality then the amount of product, which will not meet your quality standards and must be discarded that will decrease, so your material cost overall material cost will decrease.

Next, energy cost obviously, energy cost is very favorably affected by automation because automated machines are programmed to work with optimal energy just the amount of energy which is needed. So, you can cut down a lot of energy costs using automation. Similarly, you have manpower costs are naturally cut down because the very purpose of automation is to do away with manpower, so, as much as possible.

Finally, infrastructure cost come down because using automation you can produce a much larger number of units in a given time, during the time that your infrastructure is going to be used. So, your cost per unit is equal to the infrastructure cost per unit is going

to be total infrastructure cost IC divided by number of units and since automation will enhance the number of units remember that is for automation. Then to be able to install automation this infrastructure that is the total infrastructure cost will actually go up because you have to install more sophisticated equipment, you have to install additional automation equipment. So, your total infrastructure cost will actually go up, but still the infrastructure cost per unit will come down because of the fact that this number of units will go up massively. So, the overall ratio will actual come down. So, you see that that using automation one can cut down costs in various ways.

(Refer Slide Time: 21:59)



Now, let us come to production volume. How do you increase production volume, assuming that you have enough material you have enough manpower and you have enough demand. So, that you can produce to the extent that you really can automation will enhance production volume because of several reasons. Essentially, you can increase volume of production if you can cut down the time to produce one job one unit product.

So, what is this time, so that total manufacturing time can be divided in under these heads production time, material handling time because to be able be produce the unit you will have to take it from machine to machine. So, the faster that you can take them, faster that you can place a job on a machine and you can take it away from it when the machining is done you will save in time. So, the production time will reduce because of

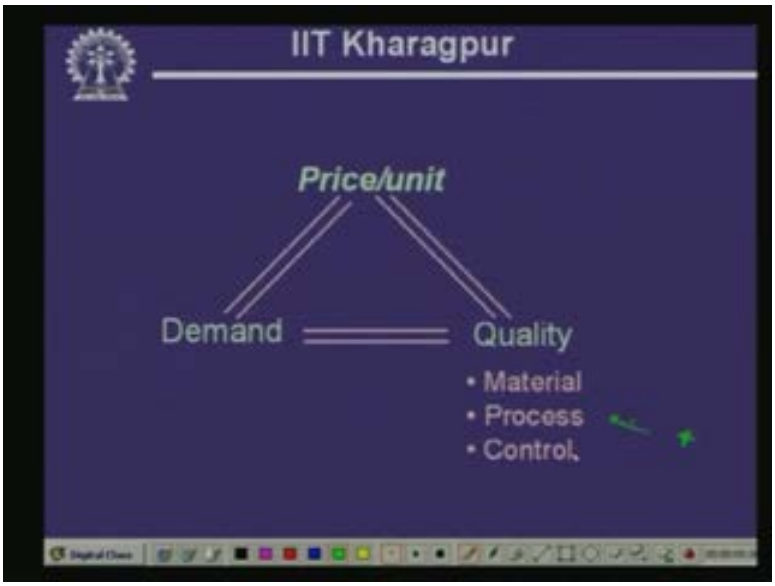
the fact that you can handle larger machines because typically various production parameters can be reduced.

So, you have reduction in production time, you have reduction in material handling time using automation equipment for material handling. Obviously you can reduce idle time because now you are automated and you are highly coordinated. You try to do the maximum capacity utilization, in fact this is the job of an area of research called resource scheduling. So, the time that the machines expensive equipments sits idle can be minimized and they can be always fed with work and finally, using automated quality assurance equipment you can really cut down on quality assurance time.

Actually, this quality assurance time is actually going up like anything because previously people use to be satisfied. You know lot by lot testing that is you pick up some random sample from a lot and you test them and if they pass you assume that the lot is every item in the lot is good, but now that is gone and people are enhancing on quality and they are saying that no. If preferably in many application like, let us say few months back I have seen that factories which produce railway lines. There was a requirement preventing accidents that of all these rails each and every rail be tested for cracks using ultrasonic test equipment.

So, unless this equipment is automated and you can very quickly test each and every piece of rail for cracks inside. You are going to consume enormous amount of time to be able to test your production, so that is how automation can cut down on quality assurance time. So, the net result is that production volume in a given time goes up massively, next the third item is how we can affect the price. Now, the price as we learnt in elementary economics that price is actually very much related to demand, this is the only place where we are considering demand.

(Refer Slide Time: 25:35)



Till now, we are thinking that there is enough demand and you can sell whatever you want. Now, it is well known that if you increase the price of an object you can increase its demand tends to increase because less people can afford it. Now, the question is on the other hand if price can be reduced then demand can be demand tends of go up that is what we see nowadays. Every day, price of cell phones are decreasing and that is resulting in a huge demand of cell phone users and then what happens to the profit equation price is reducing, but demand is then increasing. So, much then that this price minus cost into demand equation overall increases.

So, that is why you sometimes try to reduce price because you know that if you reduce it by a by some amount then the demand will increase by so much amount. That is when the profit equation gets multiplied by demand when the profit equation gets multiplied by demand then you can really gain. So, you can effect demand by cutting down price and still make more profit, if you can cut down cost because price minus cost you can remain constant price. You can reduce then price minus cost remains same, but demand increases that is the way you can make more profit.

On the other hand, if you have demand, and if you can make an item of higher quality and if you can establish that your product quality is actually higher. Then you can charge more price for it and still there will be the demand. Typically, if you go to TV shop you will find that one brand sells at a significantly not less, one brand could sell at one third

more trice, 30 percent, 40 percent more price than the other brand. Still people come and by that brand, why because people have a feeling that that brand actually has higher quality.

So, if you can enhance quality then you can increase the price and your demand will remain more or less same. So, through that part also you can make more profit. So, you can make profit either by cutting down the price or increasing the quality and charging more price both ways. That is the reason why there is an obsessive focus on quality. Now, where does quality of a product come from quality of a product, obviously comes from its materials used, it can also come from the process of manufacturing which is extremely important.

Now, this process of manufacturing as you will see is can be highly effected by automation. For example, you are trying to make machine, if you are try to make a computer numerically operated machine. Then the manufacturing tolerance the dimensions that you can produce can be significantly larger, this is very much enhance by automation.

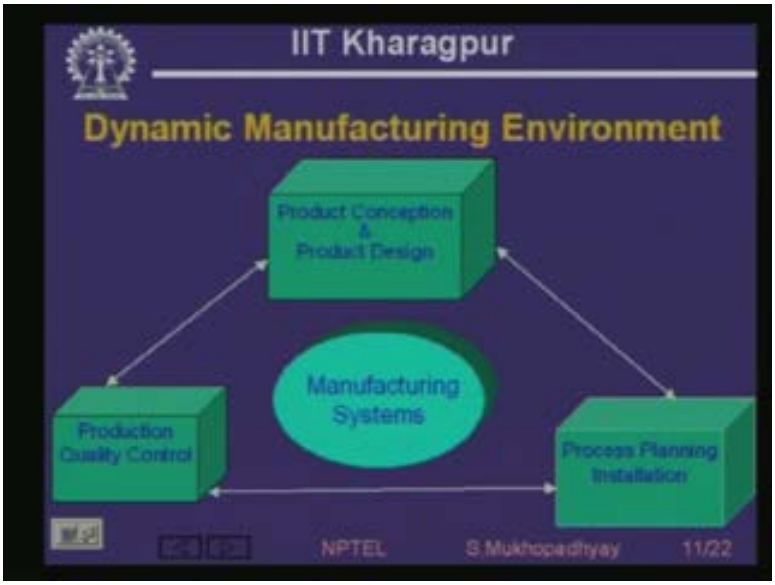
Similarly, it is also even if you give have a process a process requires very close control. That is you have to even if you have a good car you have to drive it well, so control is the driving. So, using automation and using sophisticated computer program you can actually realize much more sophisticated control algorithms. So, that will also give you much improved quality. So, in this way automation can enhance quality which will in turn enhance profit.

Now, in all these cases what we were discussing is how to produce a particular product better so that you can make profit out of it. So, as we have seen that this is typically related to what is known as auto economy of scale, if you can produce a product in a much larger volume by using very sophisticated machines because of the blessings of automation you can gain lot of profit.

That is called the economy of scale, but there is a totally different kind of economy which is becoming more and more important. In which it has first a shown its significance, in the latter half of the twenty centaury and it is going to be all important in the twenty-first century and that is called the economy of scope. Now, what is the economy of scope, to be able to understand that we have to first see look at look at the

manufacturing environment, so the manufacturing environment today is actually very dynamic.

(Refer Slide Time: 31:02)



Now, what we mean by that to able to understand that you have to first understand that how a given product, what is the life cycle of a given product that is right from the time of conception what are the phases though which it goes. So, that it finally, is produced and sold in the market an eventually dies the life of nature death. Another product comes into existence gets conceived gets designed gets manufacture and gets sold. So, every given product actually has a particular life time.

So, to be able to understand that the first phase is product conception and product design. After that you have if you want at this stage you have conceived a product that you want to make this thing, after that you want to and you have also designed it, but once you have designed it. You have to actually plan and you have to actually install equipment, so that you can manufacture it. So, you have to setup your factory you have to change your production facility right after that you have to actually do production.

That is when you have to actually do production and you have to do quality control and at this point of time, it will go out of the factory into the market place and you will get sold. Now, in the market place from the market place you will get feedback, you will get feedback of various kinds from consumer surveys plus there is continuous R and D is going on. So, people are going to come up with better material with better manufacturing

processes with better controls, which will enable you to do conceive new products, which are improved, which will sell much larger probably cost of production will be less.

So, you again conceive a new product again you design it again you make process planning installation and again you produce. So, you see this is cycle that a product from its time of from its time of conception up to it is up to its time of selling has a certain life. Now, this life is crucially affected by manufacturing systems. So, now let us look at what is happening to this situation.

(Refer Slide Time: 34:12)

So, here we have the economy of scope and what are it features. See competition and R and D are continuously causing product development continuous product development is going on. So, all old products are getting replaced by new products and this is continuous, which means that product for a given product its life cycle is getting continuously reduced.

Look at the PC market today roughly in six months time you are getting newer and newer versions of PCs. Change is coming from the cabinet to power supply to motherboard to RAM displays to software everywhere there is change. Now, these are very sophisticated equipment, just imagine that an equipment as sophisticated as motherboard has to be designed. It has to be produced it has to be marketed sold and after six months it is going to be default if you can to be obsolete to be replaced another product.

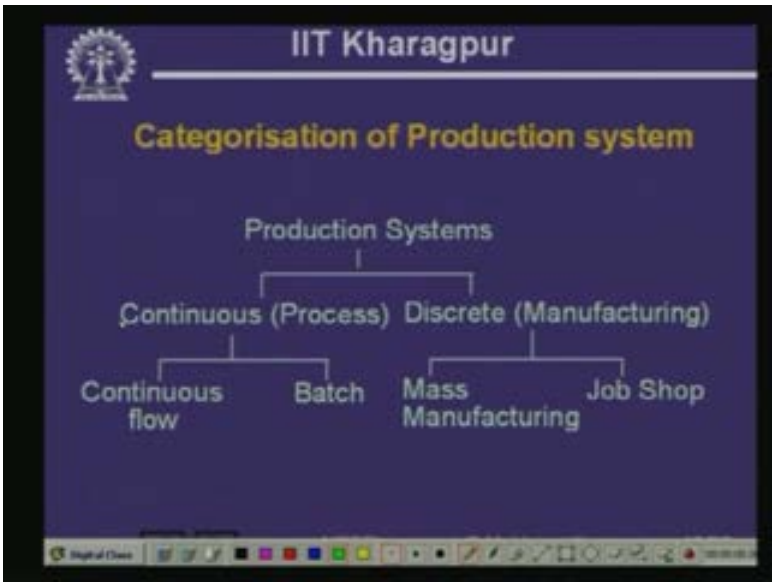
So, within six months it is everything will have to be done product will have to be sold and profits will have to be made. So, the product lifetime has shrunk dramatically. What does it mean? So, it means that product life cycle within product life is less. So, the whole product life cycle of conception design process, planning, installation, production, everything will have to be accelerated. How can you accelerate it? You cannot accelerate it, you cannot make new and new designs very fast you cannot produce them fast without having manufacturing systems which are rapidly reconfigurable.

So, you have to have machines which can today make PCPs like this tomorrow make PCP is totally entirely different make PCPs. So, they have to be rapidly reconfigurable and therefore, you need this all. So, how can I manufacturing system be rapidly reconfigurable, it can be a rapidly reconfigurable only with the help of automation. So, unless you have that is one aspect, second aspect is that unless suppose you have built a machine.

Now, if the machine is machine may be very good fantastic absolutely efficient for a product X. Now, it is only meant for product X then you will always think in this volatile market that suppose product it goes out of fashion, what is going to happen to my machine I am spending so much money on it, secondly using this machine. If there is not enough demand, so, a product takes can I also manufacture product Y from the same machine. So, can I explore other markets, so can I rapidly reconfigure my manufacturing system.

Sometimes I manufacture product X, sometimes I manufacture product Y and sometimes I manufacture product Z. If I can do that then I can utilize my machine and I can take the benefit of three different markets. So, for this also reconfiguration is necessary. So, this is what the economy of scope is and twenty-first century automation systems will enhance this economy of scope significantly. Now, let us took let us look at the kinds of the kinds of production systems that typically exist, there is a broad categorization of production systems.

(Refer Slide Time: 38:10)



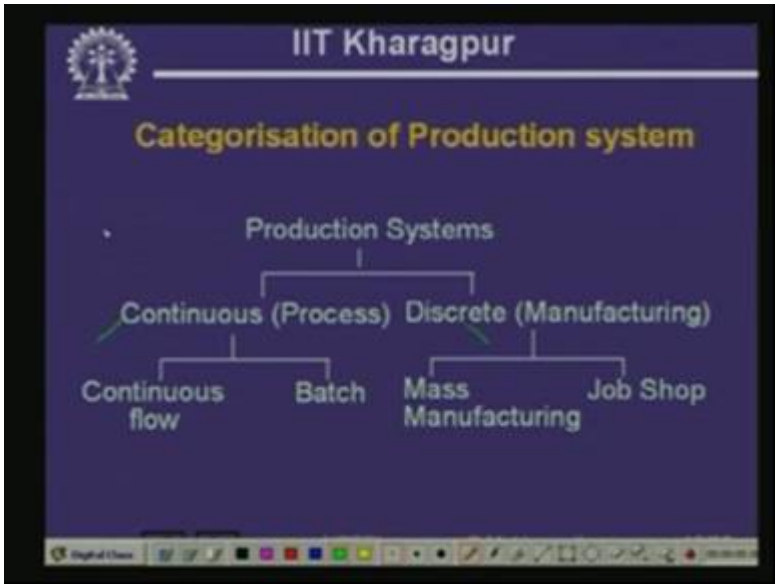
So, typically production systems are categorized broadly into continuous processes and discrete manufacturing. So, things which you can count as 1, 2, 3, so you have watches you have bicycles this is manufacturing discrete manufacturing. On the other hand, things which you generally measure not as numbers, but as quantities like oils steels cement that is a continuous process.

So, again continuous processes could be divided into two kinds, one are called continuous flow processes. Typically, means that a product is manufactured for a considerable amount of time and continuously the product manufacturing goes like the case. Let us oil refinery or the case of steel plants very big factories manufacture may be four five kinds of products, let us say gasoline petrol, kerosene these are typical product types of a refinery.

Similarly, you could have a batch process where the product quantities are more, I mean product varieties are more in number, but the product quantities are less. Typically is pharmaceuticals or let us a say paints. So, you have a large number of larger number of products, they are still continuous processes, but each gets manufactured in smaller quantities. Exactly similar categorization exits for discrete manufacturing, one kind is that where there is less number of varieties gets produced in huge numbers. Let us say bicycles or some appliances some factories produces mixers or produces televisions or produces.

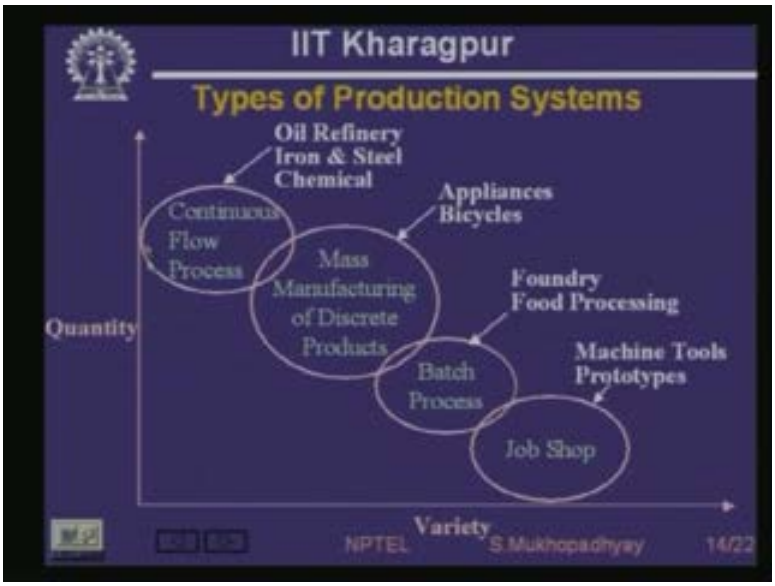
So, on the other hand contrasted to that there is a kind of practical job shops. For examples let us say let us say a machining factory. So, every customer comes with a drawing, so with a new drawing. So, every piece that you are manufacturing probably every customer gives an order of 100 pieces, 2000 pieces like that, but every customer comes with a unique product, which not only involves different geometries. But also might involve different manufacturing processes like turning, reeling, grinding, milling and they may be applied in different sequences, so every job is new.

(Refer Slide Time: 41:12)



So, this is a categorization of production system and if you organize them.

(Refer Slide Time: 41:25)



Then, you will see how they look on the quantity variety chart. So, on this side this is graft and on this side you have the quantity for each given type of product. On this side you have variety of the types of product that the factory produces. So, these are continuous flow processes, where the product variety is probably is lowest 3, 4, 5, but huge quantities of that of each product gets produced. So, some basic industries like oil refinery, iron and steel some chemical cement paper, fertilizer. So, these are typically continuous flow processes.

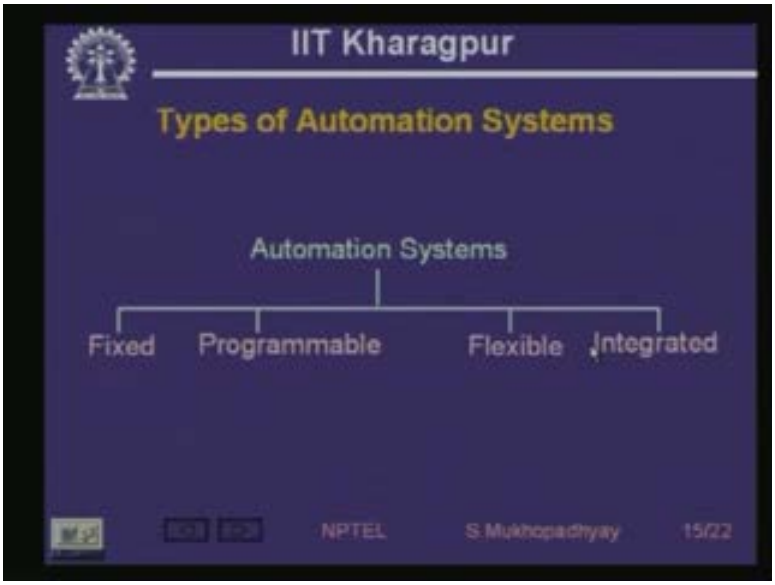
On the other hand, discrete manufacturing is the counter part of continuous flow processes. There you have mass manufacturing of discrete products appliances bicycles as we have discussed. In continuous processing, you have foundry shops where you know molten metal gets becomes casting and then casting each casting is actually different casting metals could be different.

So, food processing various kinds of various kind of foods get prepared. So, here again variety is more each variety production quantity is less and at the extreme you have job shops where every product that you are getting is likely to be a new product. So, basically what we are trying to categorize these production systems into.

Firstly, in terms of the quantity that is produced, secondly in term of the types of products. So, the flexibility required in manufacturing, so now we will see for these

various types of production systems how the various types of automation systems, they are each one will be now suitable for given types of industries.

(Refer Slide Time: 44:01)



So, let us see the various types of automation systems again categorized into four types. So, they are fixed automation, programmable automation, flexible automation and integrated automation. So, let us see what each are.

(Refer Slide Time: 44:22)

So, if you go to flexible automation a rather fixed automation first. So, in fixed automation you have, what are the features, the features are that you have generally used

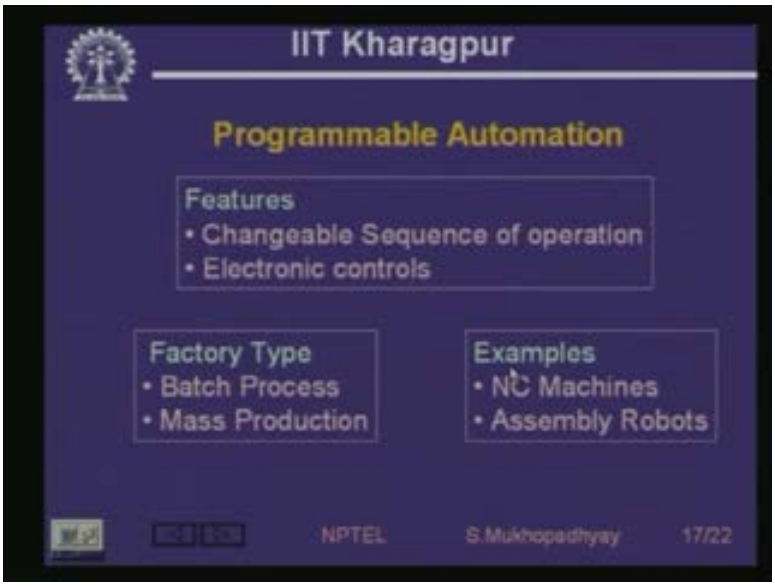
for very high volume of production. So, you need to really tune your automation to that particular production equipment is very dedicated products are not likely to change. For example the iron and steel industry cannot really, I mean the product variations is there because of metallurgical research etcetera, but it is much slower process and generally products life times are much larger.

So, there you can and the volume is so large that by building dedicated equipment you gain. So, much money that it make sense to have dedicated equipment, which is low in flexibility, but very high efficient for that manufacturing process. So, you have basically you have a very fixed and efficient operation. So, for example the let us say the blast furnaces or the or the steel melting furnace or the continuous caster these are equipment which are likely to have a long life. So, they handle so much of equipment, so much I mean, so much of materials. So, much of energy that it make sense to make them very tune for efficient production.

So, factory types typically continues flow and discrete mass productions cycles most part of the cycle are likely to live for a much longer time than, let us say let us say a fancy watch. So, examples are process automation controls for these kind of you know steel oil refinery kind of things. For example there are some part of automation which do not need to be changed, when there is not much to be changed, for example conveyers, conveyers remain nearly same always, so that is a fixed automation.

Paint shops generally painting is that you need to put the object at one place and you need not any to jet spray jet the paint. So, the operation itself is simple is not likely to change very much transfer lines. So, for example, the Maruti 800 stays the Maruti 800 for a long time keeps changing, but changes are not very significant changes. So, each part remains unchanged for reasonable lengths of time to make, I mean make the investment on dedicated equipment meaningful. Now, gradually if you go for let us go for programmable automation, programmable automation is one where you need to make changes more frequently.

(Refer Slide Time: 47:23)



It May not be everyday may not be every hour, but you still need to make change perhaps once in a week or once in a month. So, since the basic equipment life is going to be much more than a month. So, you need to make it programmable, so that is reasonably easily you can change these change the sequence of operation. So, it has changeable sequence of operation and it has electronic controls. So, that is why it came first, it came into an existence in numerical controls for discrete production.

So, again you have batch process, you have mass production, where you still have mass production, but now your product variety is increase, so you need to make changes. So, it should be reasonably fast probably need not be done operators, but it can be done by engineers within let us say if you want to change it every month then probably for changing you need to take less than a day that kind of automation. So, examples will be let us say numerically control machines various kinds of assembly Robots which will which will pick apart and put it in a different place.

So, if the sequence changes in this assembly Robots also needs to be change. So, that it can now pick part from a different place and place them at different place perhaps. Contrasted to this as the economy of scope increases, we have we have various kinds of industries where things will change very fast. So, there we have flexible automation, so now changes will be made several times in a day and changes will have to be made by operators.

(Refer Slide Time: 49:12)

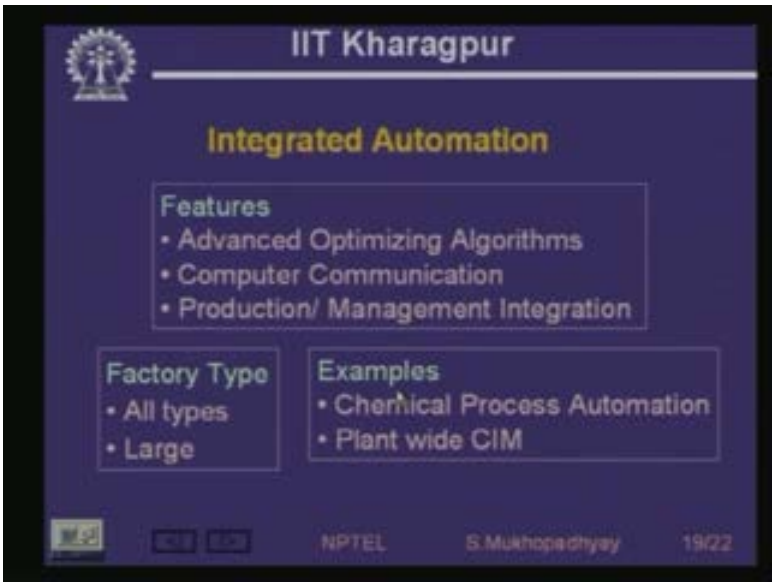
So, they have to be made fast because if the change takes time then you are going to lose out on idle time, you have to you want to maximize production time. So, machines are now computer control may be with graphically user interfaces. So, that the operators know how to operate it and can give very, you know I mean many of these changes should be preprogrammed. So, that the operation just, so the operator typically you know chooses certain configurations from a makes a choice probably adjust some parameters and the rest is done automatically.

Similarly, material handling should be also programmed because if the sequence changes then parts will have to travel from one place to another. So, if you use material handling equipment for which is fixed. Then you cannot transfer parts from one place to another very flexibly that is why you need programmed material handling. So, factory types or job shops where you know every part requires a different sequence and also could be batch processes, where depending on you know batch size the sequence of process operations will change.

So, the examples at CNC machining centers and guided vehicles automatic guided vehicles. Now, still all these that is fix programmable and flexible they are mainly concerned with automation over a limited special range. So, we are talking about local automation may be may be may be within a shop or may be within parts of a shop or may be involving just one or two machines.

Now, if you want to really control the whole factory in a very integrated manner and in a very optimal manner. Then, what you need is that you need to excise this automation you need to integrate all the automation systems and make them coordinated and make them talk to each other.

(Refer Slide Time: 51:20)



So, that is called integrated automation, where you have whole factories under automation systems. So, what are these features first feature these are actually, they are the most expensive verity of automation. Firstly, characterize by advanced optimizing algorithms that is there is a lot of knowledge built in to these machines. They actually do mathematical calculations based on very sophisticated models and there are very few venders who have got that knowledge and they generally do international business.

So, I mean international companies they are steel making consultants and they make they give their consultancies to factories the world over. So, they use very advance knowledge and algorithms obviously based on computers. Then one of the essence of these factories is that they have a lot of communication, so have to integrate various parts. So, you have computer communication and here gradually the trend in automation is that production and management must be integrated. That is right from these the order bookings at the marketing officers, they must be quickly I mean very you know whole all aspects of the business may be harmonically operated.

So, if you have suddenly get more order immediately material procurement may be go may be going on production facility augmentation will go on inventory capacity will be change. So, things are tuned and just operate like an orchestra, so there is this is what gives the name of integrated automation. So, typically this could to be applied to all types of factories, but since they are so expensive.

So, it generally they are actually applied to a very large factories and because otherwise the cost cannot be justified. Typical examples are let us say a chemical process automation, big chemical process automations and or otherwise plant wide CIM which stands for computer integrated manufacturing. So, now we have seen that as we go from for various kinds of factories you also need various kinds of automation for them.

So, for machine since steel plants you may be requiring very fixed type automation locally, but for coordination. For example, coordination between the steel melting shop and the continuous caster is a in the steel melting shop you are pouring out hot steel. So, this hot steel has to be taken by a material handling system to the continuous caster where it has to be cast. Now, if for some reason this continuous caster and steel melting shop are not synchronized then your ladle in which you are carrying the hot metal.

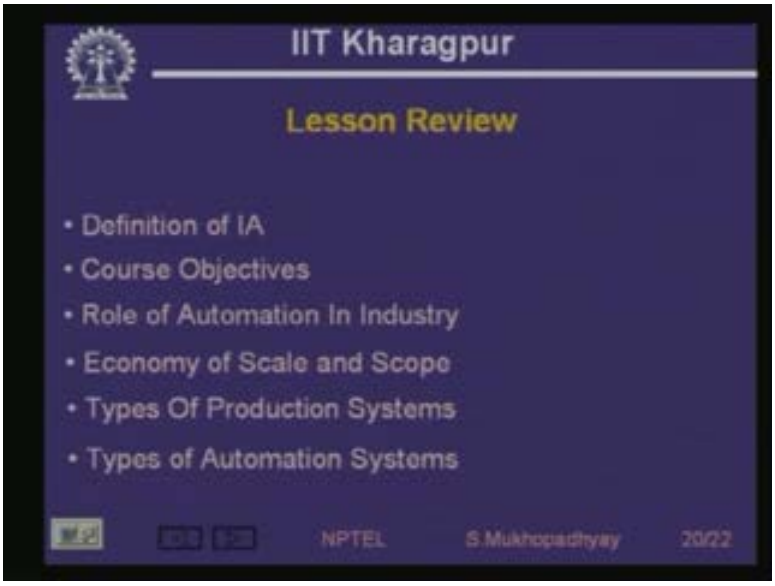
You are taking to the caster that may have to wait at various places due to various problems and in this process it may get cold. In the continuous caster if there are certain conditions, I mean you can only pour this steel into the continuous caster when the steel has certain temperature. So, if due to coordination lack you cannot ensure effective coordination, there it may happen. That you can suffer very large loses because particular ladle could not be put into the continuous caster and have to be say put in to the slab caster, where this steel will sell at much lower price. So, for steel factories you need one kind of combination.

On the other hand, nowadays if you have a bicycle factory there are people are thinking that people will book orders on the net. People will assemble their own parts on the on the web and given an order for a customized cycle for that customer. So, you will choose a particular type of seat a particular type of handle bar a particular type gear ratio wheel, diameter tire type, so every order now becomes a customized order.

So, you see factory which was essentially a mass manufacturing has it is trying to manufacture the same volume, but it is time to increase these variety just you capture markets. So, and this is being made possible by very a advanced automation. So, this brings us to the end of our lecture and before we end, let us review our lessons. So, what have we done today we have seen a definition of industrial automation and we have discussed about automation control, we most of us know because we have already had a course in control.

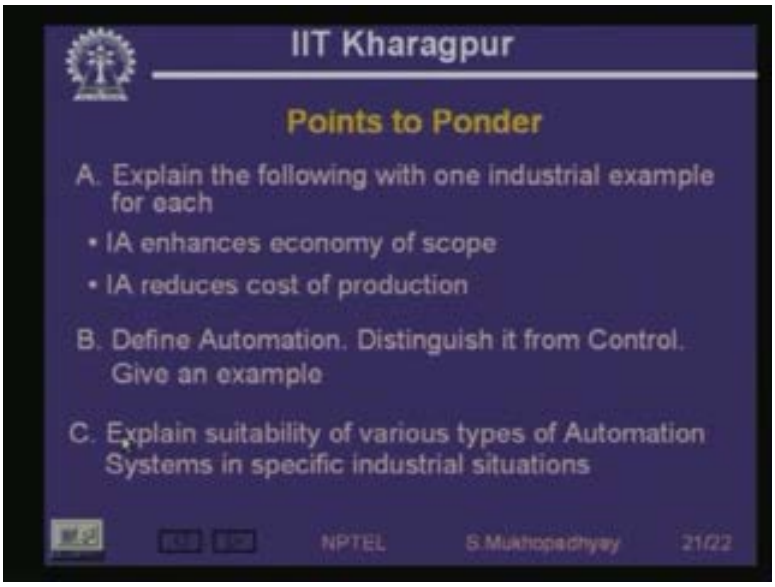
Actually, control is actually a part of automation and actually talks about only the day to day, I mean minute to minute operation giving input getting output. That is called control while automation is much larger in scope both geographically and overtime and over functionality, so we have seen that definition.

(Refer Slide Time: 56:43)



Then we have defined our course objectives. We have underlined the role of automation industry and how it can help you on profits. We have distinguish between economy of scale and scope we have, I mean shown the various types of production systems and their different types of automation systems. So, this is what we have done in brief.

(Refer Slide Time: 57:08)



Here are some questions, which you can look at for example, you could try to give examples of how industrial automation enhances economy of scope. You can give an examples from a particular type of industry. You can also enhance in a given industrial context how it reduces cost of production. You can define automation and distinguish it from control, give it an example or explain suitability of various types of automation systems in specific industrial situations. So, that is all for today. Thank you very much. We will see the architecture of industrial automation systems in our nest lesson.

Thank you very much.