

**INDIAN INSTITUTE OF TECHNOLOGY
KHARAGPUR**

**NPTEL
ONLINE CERTIFICATION COURSE**

**On Industrial Automation and
Control**

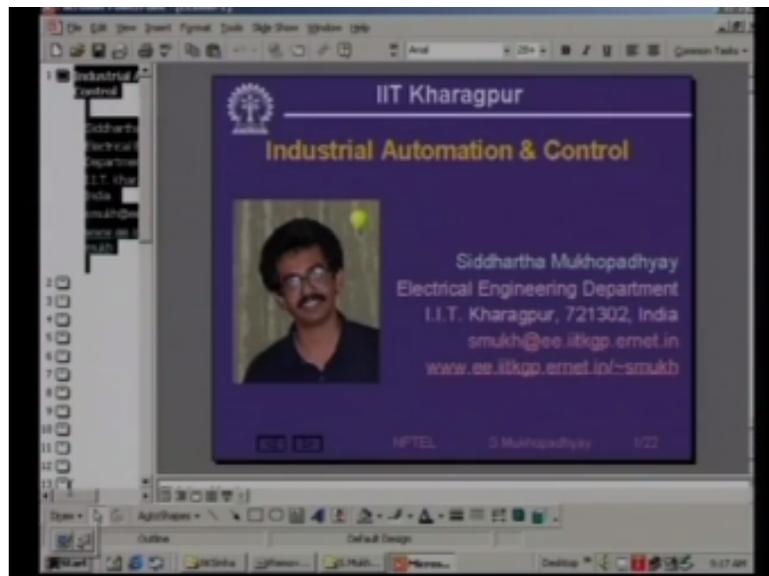
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**Topic Lecture – 01
Introduction**

Keywords: Automation, control, infrastructure cost, energy cost

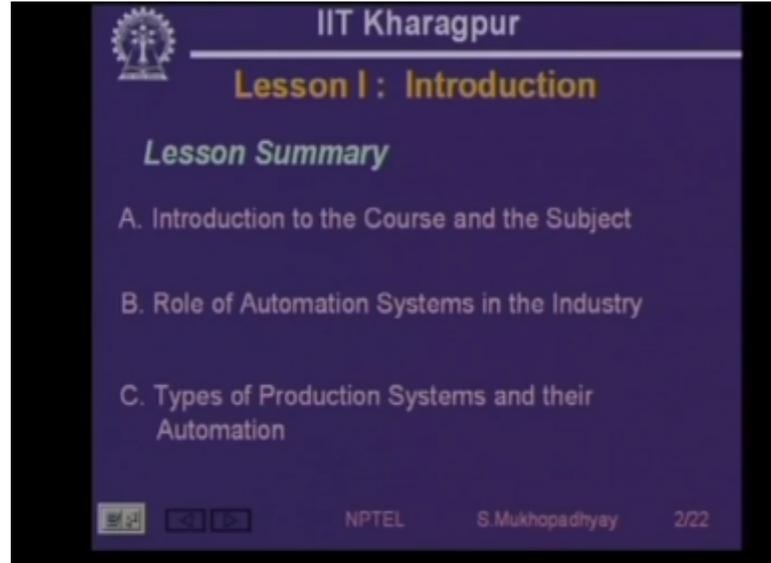
Good morning this is a course on industrial automation and control recorded under the NPTEL program at IIT KHARAGPUR I am Siddhartha Mukhopadhyay.

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Of the department of electrical engineering at IIT Kharagpur, today we are going to look at the content of lesson 1, so let me start my presentation. So, this is a course on industrial automation and control and.

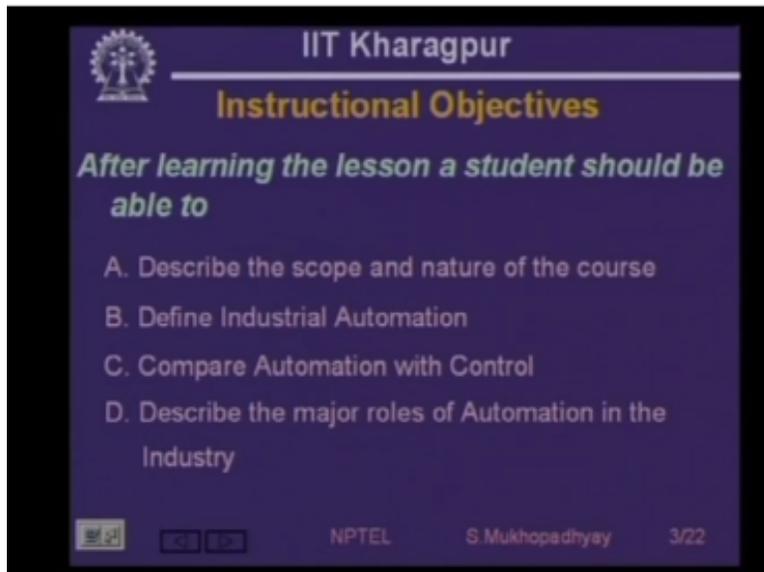
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The image shows a presentation slide from IIT Kharagpur. At the top left is the IIT Kharagpur logo. The text on the slide reads: "IIT Kharagpur", "Lesson I: Introduction", "Lesson Summary", "A. Introduction to the Course and the Subject", "B. Role of Automation Systems in the Industry", and "C. Types of Production Systems and their Automation". At the bottom, there are navigation icons, the text "NPTEL", the name "S. Mukhopadhyay", and the page number "2/22".

We are going to start with the first lesson which is on introduction, that's before we start on let's 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 good, 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's what we are going to do in this lesson broadly speaking.

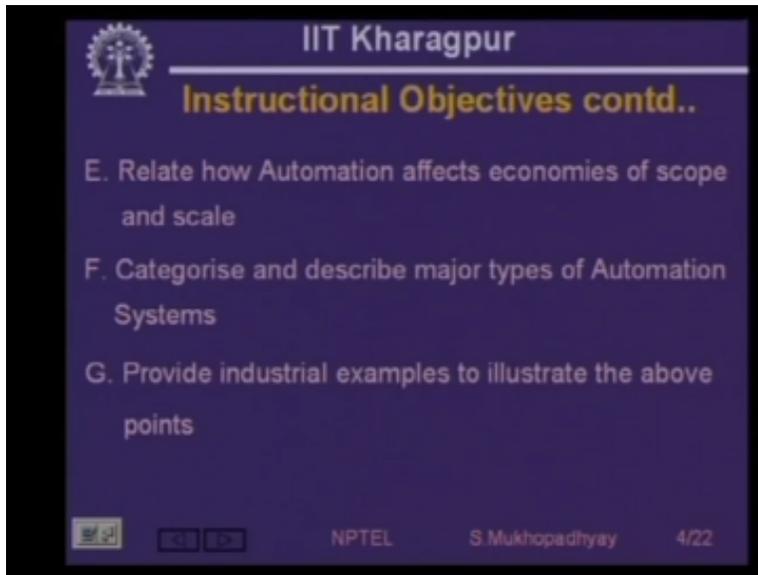
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The image shows a presentation slide from IIT Kharagpur. At the top left is the IIT Kharagpur logo. The title "IIT Kharagpur" is at the top right, and "Instructional Objectives" is in the center. Below the title, it says "After learning the lesson a student should be able to" followed by a list of four objectives: A. Describe the scope and nature of the course, B. Define Industrial Automation, C. Compare Automation with Control, and D. Describe the major roles of Automation in the Industry. At the bottom, there are navigation icons, the text "NPTEL", the name "S. Mukhopadhyay", and the slide number "3/22".

Before we start off first of all we need to understand the instructional objectives, that's what is it that a student is expected to be able to do after going through this lesson. So after learning the lesson a student should be able to, A. describe the scope and nature of the course that will, you know give an 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 that that automation plays in the industry.

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And he will be able to relate two terms called economies of scope and economies of scale and see how automation enhances these, he will be able to categorize different types of industries and describe the major types of automation which are suitable for each kind and finally he will, be he 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, is to go to, and go to a good dictionary and try to find out the meanings of the words which constitute the term.

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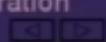
Defining Industrial Automation

Etymology

Industry	Systematic Economic Activity Manufacture/Service/Trade
Automation	"Auto"(self) + "Matos"(moving)

Definition

Industrial Automation is a set of technologies that results in operation of industrial machines and systems without significant human intervention and achieves performance superior to manual operation



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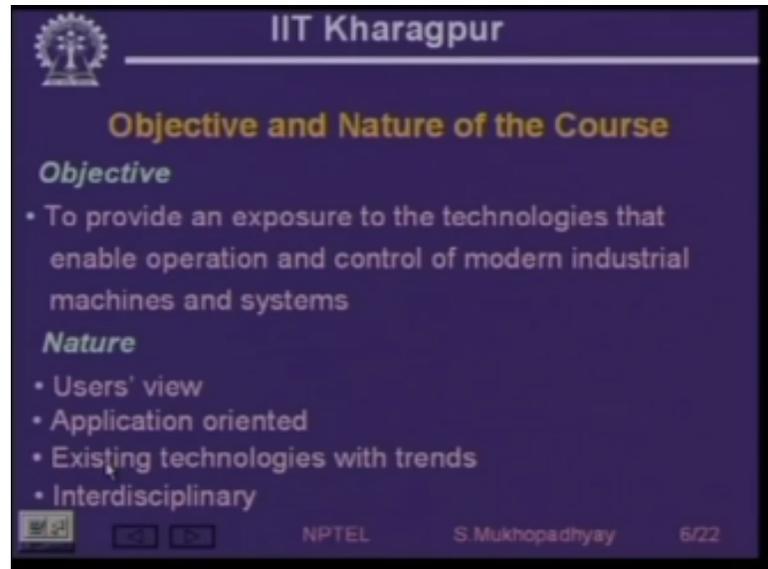
So let's look at the etymology of the name industrial automation. So what does industry mean in a broad sense an industry is nothing but a systematic economic activity, now economic activity means what economic activity may be related to manufacture it may be related to service or it may be related to trades .In this course, we are primarily concerned with manufacture so we will essentially be talking about manufacturing industries right, next is 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, and another means another is the word Matos or moving, so together an automaton is a device or an object which moves by itself.

So now this is the this is the essence of the word automation and from this you can very easily understand and the the definition of automation which I have coined. 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 and 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 and 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 these, this is, the this is a definition of the

word automation which I have coined. Now let us look at the objective and the nature of the course.

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The slide is a presentation slide from IIT Kharagpur. It features the IIT Kharagpur logo in the top left corner. The title 'IIT Kharagpur' is at the top center. Below it, the main title 'Objective and Nature of the Course' is displayed in a larger font. The slide is divided into two sections: 'Objective' and 'Nature'. The 'Objective' section contains a single bullet point: 'To provide an exposure to the technologies that enable operation and control of modern industrial machines and systems'. The 'Nature' section contains four bullet points: 'Users' view', 'Application oriented', 'Existing technologies with trends', and 'Interdisciplinary'. At the bottom of the slide, there are logos for NPTEL and S. Mukhopadhyay, along with the slide number '6/22'.

The basic objective of this course is to provide the student with an exposure, 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 atleast something about these would be familiar to an extent about these technologies which typically exist in an industrial facility.

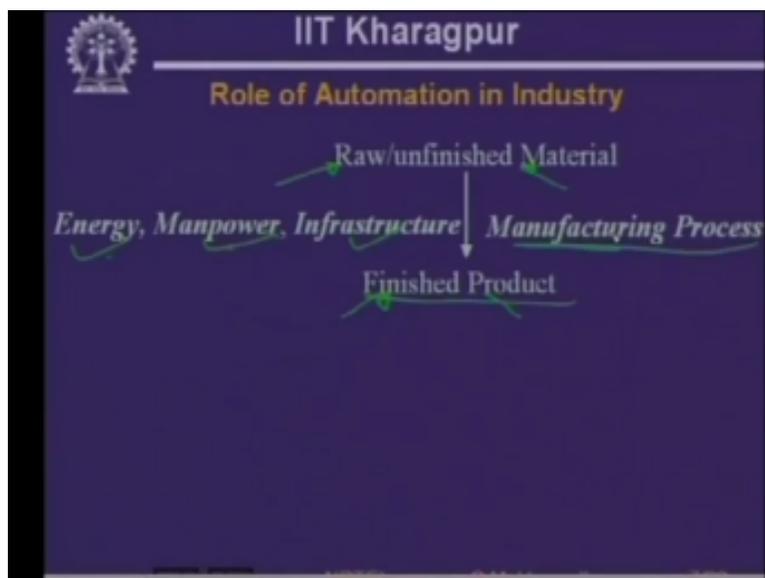
Keeping this in mind the the nature of the course is, firstly essentially we want to provide a user's view whenever you are discussing a technology you can either take a user's view to provide an exposure to basically an understanding of how things work may be some amount of integration how things can 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 is how to design and make those machines now that's that's that's an order of magnitude more complex a task and in this course we are not going to attempt that.

We are also most of the time we are going to be very focused on on applications so when we discuss control we are not going to talk about abstract transfer functions which we call plants

rather than that we are we are going to talk about transfer functions all right but we will always make it explicit that's what this transfer function stands for what is the physical object, why is it used, so the so the actual application context will will 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 delve too much into the trends or too much into research and finally we are going to embark on a discussion which is essentially interdisciplinary, so it's not going to be a discussion only related to electrical engineering but we 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's first take a reasonable look on the role of automation industry.

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This is very important to understand because this is the only lecture where we will where we will discuss the kind of technologies that we are going to discuss for the next several lessons, how

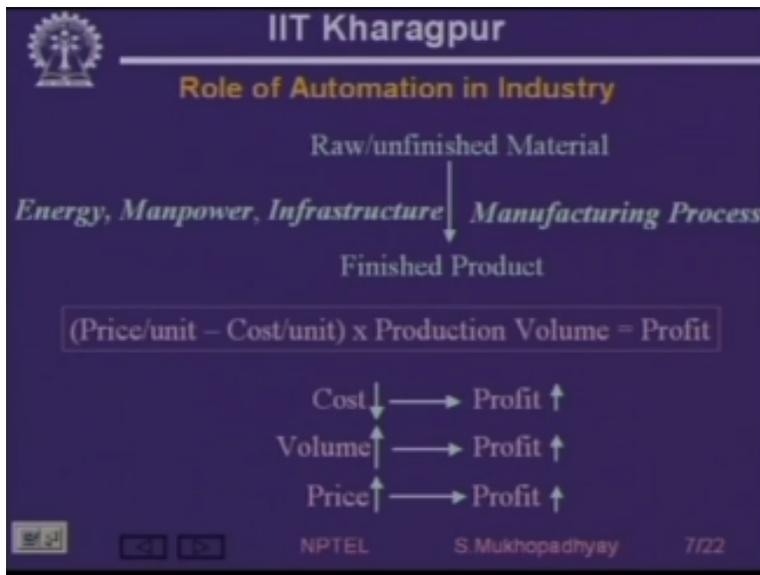
these technologies actually produce an effect which is, which is considered a tremendous advantage from the point of view of economy. So let's first try to understand since automation is for the factory let us first try to see what basically a factory does, so a factory essentially, a factory essentially starts with raw or unfinished material it could be either raw material, for example in an iron steel factory you start with iron ore that's your raw material.

And you produce a finished product which in this case is steel, on the other hand it could also also start with some unfinished material which is so you so when you when you 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 product.

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 etc. so so all these I have categorized into three different types one is energy another is manpower and other is infrastructure and using these and through a manufacturing process the raw or unfinished material is transformed to a finished product right.

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 systemic economic activity the basic goal is obviously to make profits now we have to understand what effects profits and we will see that automation affects almost every aspect of profit making that's why it is so crucial for the success of an industry so to so to make that point let us define a very simple equation which says.

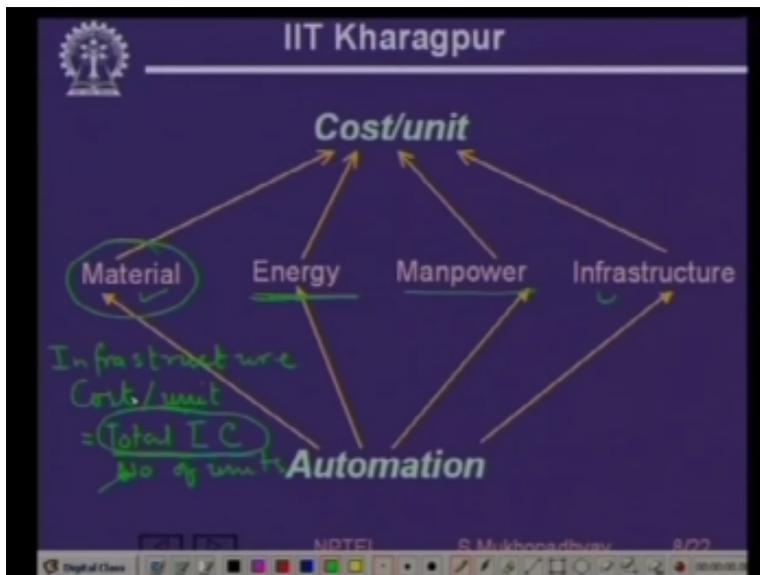
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That profit is price per unit minus cost per unit into production volume here we are assuming that whatever you produce you can sell so over a given time the profit you will get assuming that you can sell it assuming that you can sell whatever you produce this is going to be the profit so from from this equation which is very simple you can easily understand what will increase profit for example for example if you can bring down costs your profit will increase right.

Similarly if you can increase the 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 costs can increase production volume and sometimes can increase price so let us look at cost per unit so cost per units.

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So, cost per unit is affected by 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 costs right so obviously the material cost is a significant part of the total cost then there is energy costs this is becoming more and more expensive energy is becoming more and more expensive not only because of the energy cost because of other costs which are associated with energy.

For example that is prevention of pollution that is the that is the cost of producing clean energy right and because of policies today state policies that cost is becoming more and more, then of course manpower costs if you are going to employ people you will have to manage them you have to make a set up all these are going to be expensive and there is also infrastructure cost, that is the cost of acquiring land, the cost of acquiring equipment, remember that the that while material energy and manpower costs are sometimes called variable costs because they are they are costs which you have to make they are which you have to incur on a on a recurring basis

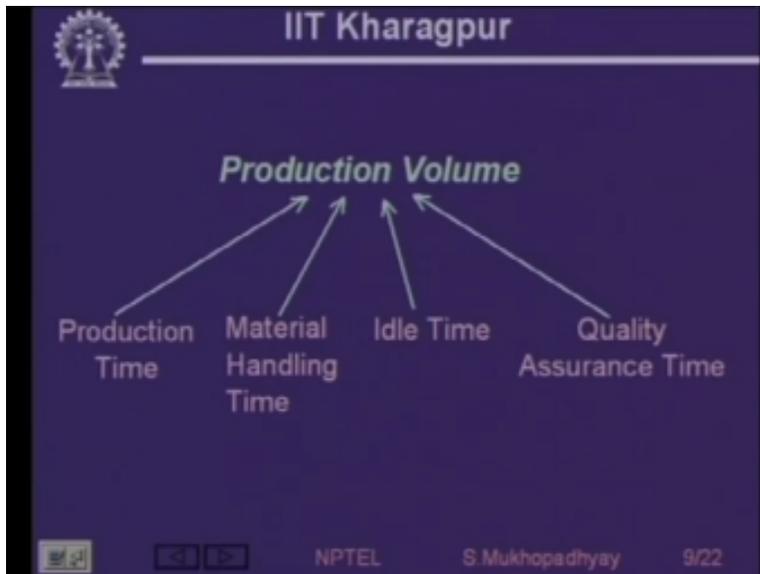
while infrastructure cost is generally one-time costs you know they are called sometimes costs they are called fixed costs.

So obviously the infrastructure cost is if you if you 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. So now let us see that how automation can really affect them, so automation can reduce material costs 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 if you have an automated machine and if you are programmed it cleverly then the amount of scrap that you generate is going to be much less, if you have better quality then the the amount of products which will not meet your quality standards and must be discarded that will decrease, so your material cost, overall material cost will decrease.

Next is energy costs obviously energy cost is very favorably affected by, by automation because automatic machines are programmed to work with optimal energy, just the amount of energy which is needed, so you can 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 and finally infrastructure costs come down because of the fact that because of a fact which is, so that 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 so your cost per unit your cost per unit is equal to that is 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 for automation, the, to be able to install automation this infrastructure that is the total infrastructure costs will actually go up because you have to install more sophisticated equipment you have to install additional automation equipment so your total infrastructure costs will actually go up but still the infrastructure cost per unit the still the infrastructure cost per unit will come down because of the fact that that this number of units will go up massively, so the overall ratio will actually come down. So you see that that using automation one can cut down costs in various ways now let us come to production volume.

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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 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 one one unit product, so what is this time so the total manufacturing time can be divided under these heads production time, material handling time, because to be able to produce the unit you will have to take it from machine to machine, so the faster that you can take them the 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.

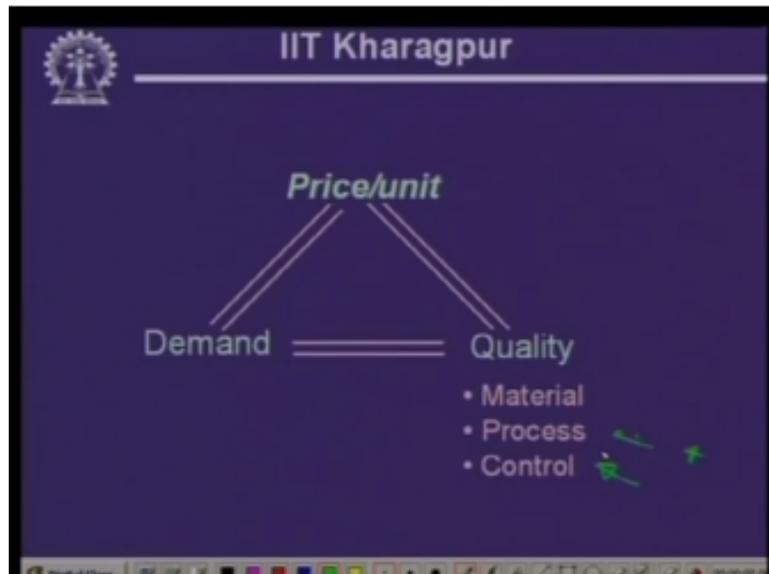
So the production time will reduce because of the fact that you can handle larger machines because typically various production parameters can be reduced, so you have reduction in production time you have reduction in material handling time using using automation equipment for material handling obviously you can reduce idle time because now you are now you are

automated and you are highly coordinated you you try to do the maximum capacity utilization in fact this is the job of an area of research called resource scheduling, so that the time that the machines expensive equipment sits idly can be minimized and they can be always fed with work.

And finally using automated Quality Assurance II equipment you can really cut down on quality assurance time actually this this quality assurance time is actually growing up like anything because previously people used to be satisfied with you know lot by lot testing that is you pick up some random samples from a lot and you test them and and if they pass you assume 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, they there was a there was a requirement for preventing accidents that of all these rails each and every rail be tested for cracks using ultrasonic testing 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 consumer 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, the third item is how we can affect the price now the price as we have learnt in in elementary economics that price is actually very much related to demand this is the only place where we are considering demand.

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

So much that 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 that then demand will increase by so much amount that that when its, when the profit equation gets multiplied by demand then you can really gain. So you can affect 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 the same but demand increases.

So that's the way you can make more profit on the other hand if you have demand and if you can make an item of a higher quality and if you can establish that your products quality is actually higher then you can charge more price for it and still there will be demand typically typically if you go to a if you go to a TV shop you will find that one brand sells at a significantly not not not less one brand could sell at one-third more price thirty percent forty percent more price than the

other brand and still people come and buy that brand why? Because people have a feeling 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 path also you can make more profit right, so you can make more profit either by cutting down the price or by increasing the quality and charging more price both ways. That this is the reason why there is an obsessive focus on quality now what is 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 is can be highly affected by automation for example if you are trying to make a machine if you are trying to make a computer numerically operated machine then the then the manufacturing tolerances of dimensions that you can produce can be significantly larger this is very much enhanced by automation right, similarly it is also even if you give a have a process a process requires very close control that is you have to 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.