INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

NPTEL
ONLINE CERTIFICATION COURSE

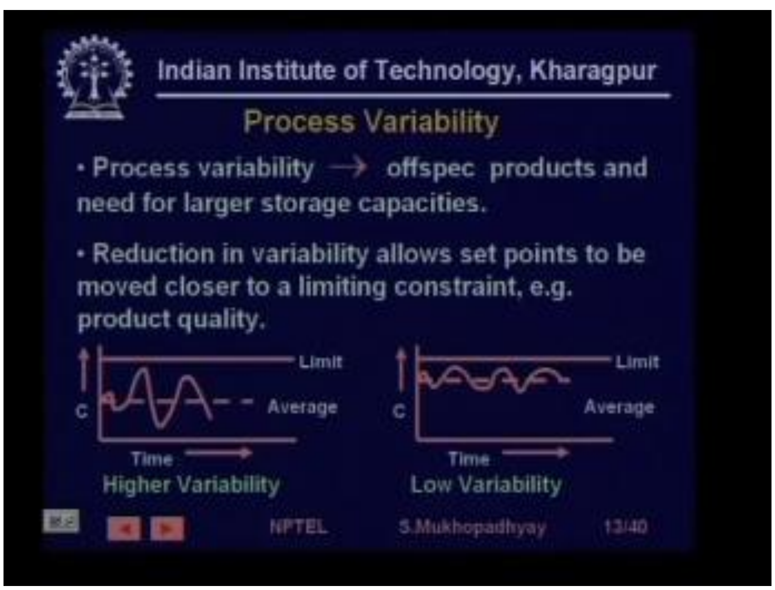
On Industrial Automation and Control

By Prof. S. Mukhopadhyay
Department of Electrical Engineering
IIT Kharagpur

Topic Lecture – 51
Higher level Automation systems (condt.)

You so there can be what I am trying to say is that in a typical industrial scenario you can have various kinds of optimization criterion.

(Refer Slide Time: 00:28)



Second thing is the second thing which is important for a for a production is that you know process variability that is typically you want to maintain a certain set point you are holding and but still the process signals or the process final product parameter let us say let us say steel strip thickness steel strip thickness something out of rolling mean you have the same role gap so you want that a steel bar comes of a certain width and when it gets rolled it should come out with a with a with a certain level of thickness right.

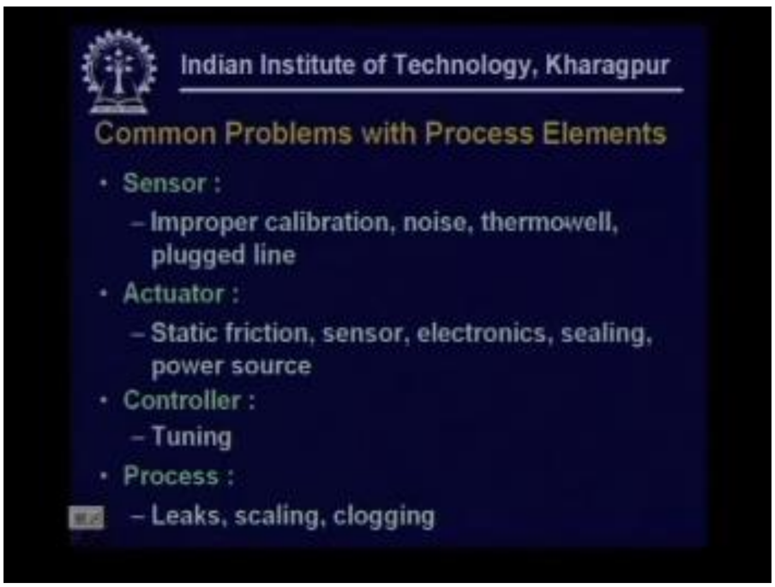
So you have accordingly you have set your accordingly you have set your role gap right so this gap is gap between the two roles you have set so your set point is fixed but it turns out that there can be enormous variations in there can be quite a bit positions in role gaps depending on other factors for example the temperature of the bar which is entering so if the bar is heated to the appropriate temperature it will get rolled easily if the bar is not heated if the bar has cooled down little bit because it was waiting to be rolled for some time so its temperature has fallen down then it will become considerably harder to roll and therefore the dimension reduction may not be appropriate right .

So such things can give a lot of process variability and you know once you have once you have a good see you want for the product to sell you need a certain quality finally so in the case of sometimes if you have if you are storing in tanks as we have said that as you 'restoring in tanks and if you have widely fluctuating product quality then you actually need a large tank such that all these variations very when they get when they actually come to the tank can finally get mixed then they come to an average point.

So if you may have a small tank then obviously integration over smaller time of a sinusoid will give a we give will still give variations so if you want reduce variation you will need to have large tanks on the other hand in the case of discrete manufacturing you are each piece is actually different so this is not that if you know manufacture more length of steel plates then you can tolerate certain some kind of variations mean variations on one part will not cancel the other.

So in such a case you know you have to you have to for example suppose a railway wheel it has to have a certain amount of weight now if you if you if you're if now when you are cutting an ingot you are first starting an in god and then shaping the ingot in the in the form of a V now even you are cutting the ingratitude if you cannot cut precise amounts of material then what is going to happen is that you will always play safe because you do not if it becomes of less volume or weight then it will be totally rejected so you will try to play safe and you will actually set your limit higher so you will cut more material then finally that that that additional material will have to be machined and you are not only going to waste material again but you are going to waste machine time. So if you have high variability generally you do not have good performance of processes.

(Refer Slide Time: 04:11)

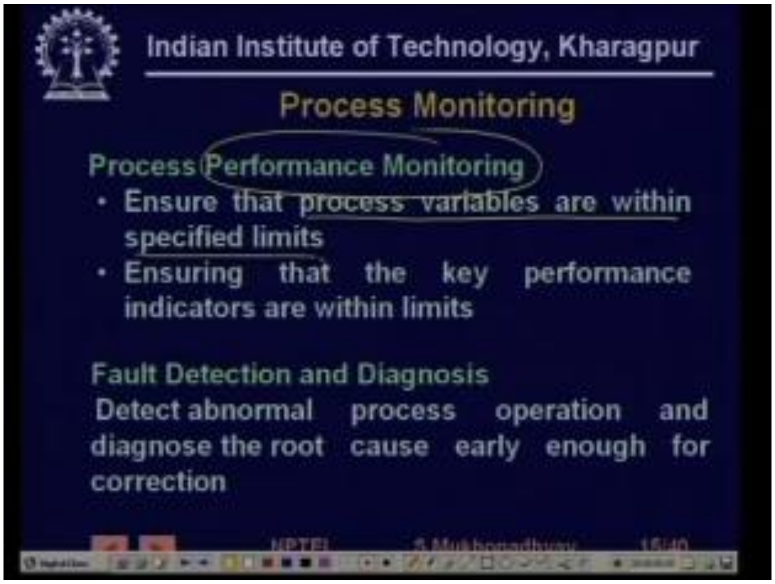


And variability big variability generally comes for various kinds of problems in processes like common problems which are like four sensors they may have there may be improper calibration improper calibration will directly result in dimensional inaccuracy if you have noise then because of noise feedback things will there will be perturbations in the output similarly thermo Wells when they get clogged the they actually can insert quite a bit of time constant and therefore especially when you have when you have things set points then the process will not track the set point well as we have learnt similarly plugged lines can give plug lines means all the sensors will actually sense so maybe you are so you are sensing a pressure sensor and you have a you have a line which actually connect the process to the meter and sensors the pressure now this this line if it is plugged then the pressure will not be properly sensed and the sensor will give bad readings.

And sensor readings prop as we have seen earlier that sensor readings sensor errors in control systems directly affect the output so if you have any problem with the sensor is going to be directly turns transferred to your output similarly you could have actuator problems various kind of problem like friction due to lack of lubrication then actuators also have sensors so there may be problems there may be problems of electronics or problems of sealing sometimes you know fluids will leak say hydraulic systems or problems of power sources for example suppose you have a pneumatic actuator and if you have if you have less air pressure or you have a hydraulic actuator and your hydraulic pump pressure has fallen so such problems give you give problems in the actuators is that you know very typical problem.

Similarly controller may maybe badly tuned right and similar and of course the process can develop leaks it can develop you know scales on heat transfer equipment things can get clogged so all sorts of all these kinds of problems can occur and these problems generally make the performance of the control loopinferior so one needs to all the time check whether the control system is actually performing adequately so that is the basic job of process monitoring.

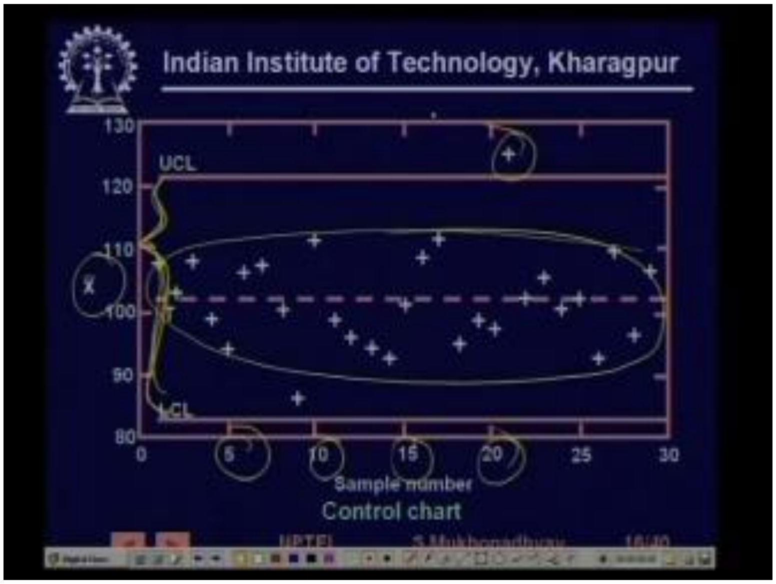
(Refer Slide Time: 06:34)



So you have process monitoring so the basic Java process that there are you can you can divide process monitoring into two ways one is performance monitoring and the other one is the other one is failure detection or diagnosis so when you are doing performance monitoring then you are ensuring that process variables are within specified limits so you are so no limits are being crossed quality will be ok and you are also ensuring that that other key performance indicators for example energy being spent or compositions of West compositions etcetera are you know scrapped the amount of scrap or the amount of raw material that you are consuming our unique product this could be you know key performance indicators or the loop dynamic performance these are within limits.

So well you are doing performance All time monitoring you are trying to look for better optimization opportunities but as such the plant is operating okay contrasted to that you have a situation where there were something goes wrong something breaks so the abnormal process operations and then you have to diagnose the root cause early enough for correction so that the it can be connected and the operation does not get GOP diced.

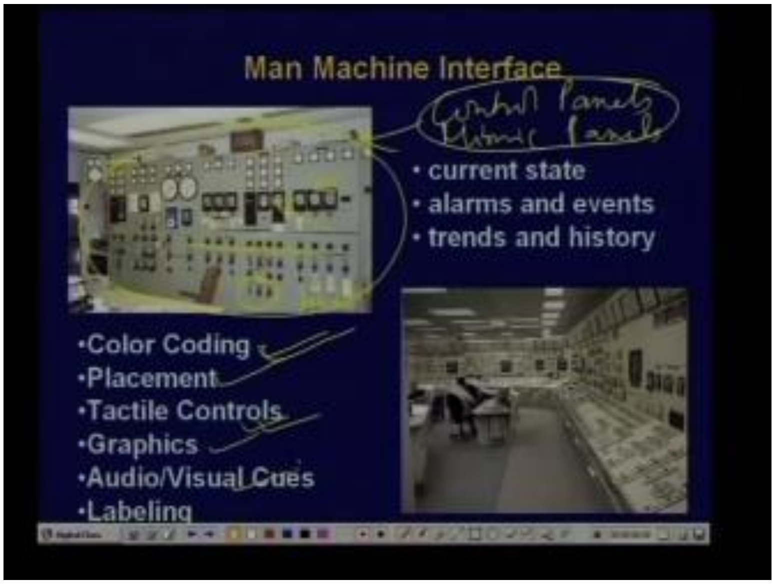
(Refer Slide Time: 08:14)



So these are the two kinds of functionality main functionality for process monitoring process variability chick this is as standard control chart so you take lots and then you from this those Lots you actually calculate means mean values and then you plot the mean values and you continuously try to see will so you have decided some upper control limit and some lower control limit and you try to see the hub that was the mean values are actually contained within that in in some cases they may go out if they go out that is cause for concern if they go out too often then they are cause for really cause for concern.

And you need and you know that your process variability has increased right so the process is not being able to follow a particular kind of you know output properties but the output properties are varying and there is a lot of variability so which means that something has gone wrong right so you need typically you check process variability using such charts.

(Refer Slide Time: 09:20)



Often process monitoring why we are showing this diagram is that in many cases process monitoring is actually done by expert operators so there is always a question of you know having man-machine interfaces and there are lots of issues in their designs like for example previously older old of this this is this is a typically it looks like a power plant power substation is a pause you know here is a bus here is the bus here the various feeders this is a probably some sort of machine.

So you have these are various meters then you have relays at the back and things like that so you see that these are you know a panel these are called control panels a mimic panel sometimes so previously what we used to have you know such mainly such man-machine interfaces where the officer you have big meters and the there so now the design of these have to be such that the that it is you know easily problems see an operator looks at hundreds of these meters so they have to be properly color-coded.

So that is an operator conform a distance you can quickly make out what is the source of the problem they are placements more important things should be right in front of the operator then the various controls should be such that the operator the operator can very closely operate it so you have you know various kinds of joysticks and other controls whether the operator can conveniently give manual control commands of course graphics audio visual clues alarm Annunciation so some lights glowing some hooters and proper labeling is each variable should be properly labeled.

So that the operator can quickly make out the situation so there is a lot of you know these are called you know human factor engineering human factor engineering sometimes referred to as I ergonomics argh anomic so there are so the lot of such thoughts go into the design of such man-machine interfaces on the other hand if you see some modern interfaces many of it will be often will be for example you can see here that apart from these the operators will have computers so there will be you know VDU CRT based displays which will also show these are the modern kinds of man-machine interfaces.

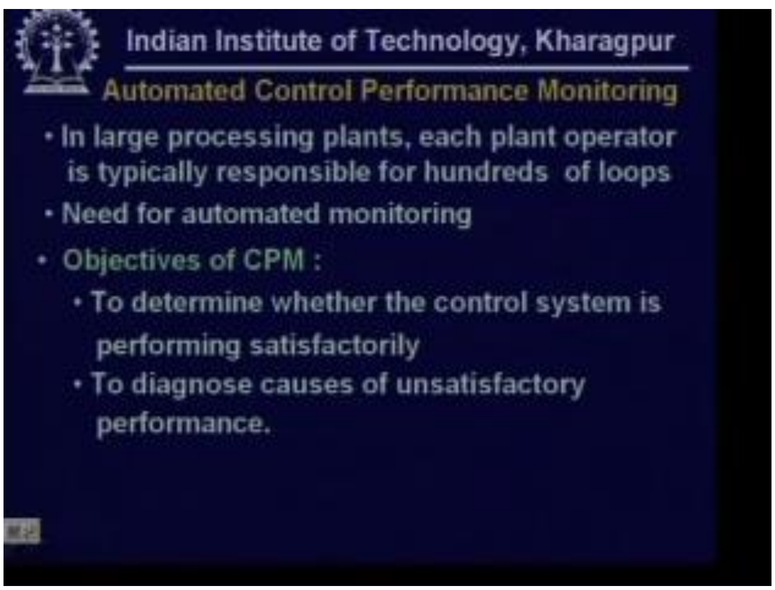
Typically a man-machine interface shows to the operator these three things it shows the current state of the process it shows alarms and events and it lets the operator compare performance against trends and history so these are the three kinds of information that a man-machine interface a modern man machine interface based on computers makes available to the operator.

(Refer Slide Time: 12:44)

So these are so it these are the major functions of man-machine interfaces data acquisition in this play then measuring processing it calculates the various derived values that is it does not always produce raw data to the to the operator because that the raw data and does not is sometimes require further processing to give more meaningful operation information to the operator for you know effective plant operation and management so such measurement processing will go on and summation processing then events and alarms it will clearly show the events alarms their sequences then etcetera.

So how the things are happening what when which signal has reached some high or low level so all these things all the sequence of events that are happening in the system it lets the operator see it maintains a history database and long generate logs and reports it also takes the operator commands and applies it to the plant and finally it integrates with the higher layers of automation like for example in this case which will be a which may be a manufacturing execution system.

(Refer Slide Time: 14:23)



So these are the main functions of now it turns out that as we as you have seen from the previous picture that there are hundreds and sometimes may be close to a thousand variables and loops that the an operator may be required to monitor so there is a need for you know it is very difficult and there is a need for automated monitoring and therefore purely manual monitoring acquires lots and lots of experience and even then operator errors are not cannot be ruled out and have occurred in various situations just like they occur in aircraft accidents a craft accidents also the pilot has to see a whole lot of signals and take very time critical decisions.

So the control performance monitoring automatic control performs monitoring actually basically tries to determine whether the control system is performing satisfactorily if not then to diagnose causes of unsatisfactory performance and then finally it generates action which could be retuning of controllers or it could be activating special shutdown or emergency procedures so this is the basic idea of performance monitoring.

(Refer Slide Time: 15:37)

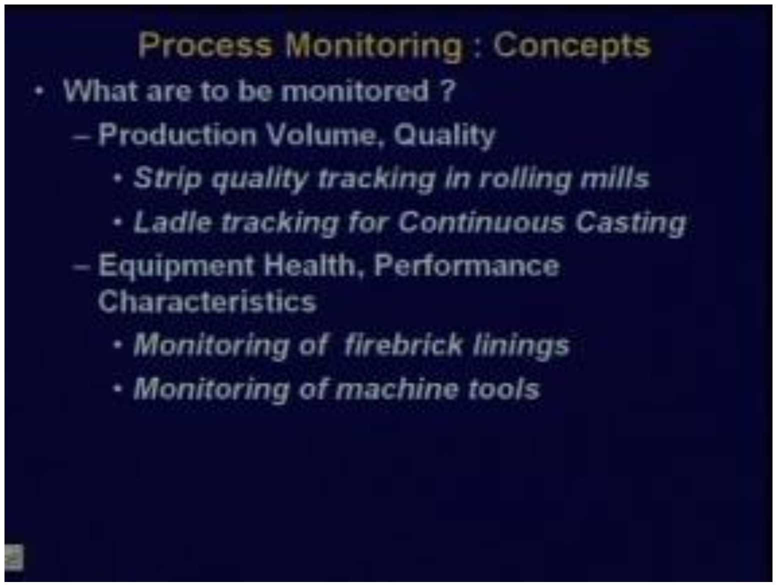
Now if you want a monitor if you want to basically determine whether something is going wrong then just a moment oh ok machine interface then yeah so we have seen this one so yeah what I was saying is that if you want to find out whether a plant is working perfectly then you need to do two things firstly you need to check with the benchmark you know something whether it is good enough so first of all you have inter mine so you're the first of all look at some quantity so what are the quantities that you are going to look at to understand whether the plant is performing properly so says so you need to select some response parameters or some performance indicator and then you need to check whether it's value is ok so you are so you need to define what is okay and what is good enough so that is called a benchmark.

(Refer Slide Time: 17:13)

So what you do is so you could we have various kinds of benchmark for example you could have response parameters like rise time settling time overshoots offsets integral error criteria so all these could serve as benchmarks so if you have a to hire overshoot then you know that there is something wrong and one of the reasons could be that the loop delay has increased for some reason maybe it maybe the maybe the sensor thermo well has accumulated some material so this is the sensor lag has increased and therefore you are getting too much overshoot because overalls loop phase has increased right.

Similarly you could you could calculate some sudden signals and we will see what this is a little more detail even if you have if you have a model of the process I mean a dynamic model which could be described in various mathematical terms then you could generate you know a residual that is you can even generate a signal theta’s long as the system and the model are closed and a half then the signal will be is going to be small if the system deviates from the model then the signal will grow up and then you can try to look at that model you can try to look at the residual or you can look at.

(Refer Slide Time: 18:22)



You can even look at historical data you know you can look at historical data saying that and which you know that this is satisfactory performance you know so you can always compare so suppose some maintenance was done in the plant and immediately after that you know that the plant was working fine so if you have the historical operational data stored with that you can always compare with that and then that can also serve as a benchmark right so there are various ways that this process monitoring can be done you can try to monitor various things like production volume production quality for example you can strip quality tracking in rolling mills or ladle tracking for continuous casting because so that you know that you can achieve a certain amount of certain number of you know heats in a continuous caster this this is this was actually a problem for hostile industry.

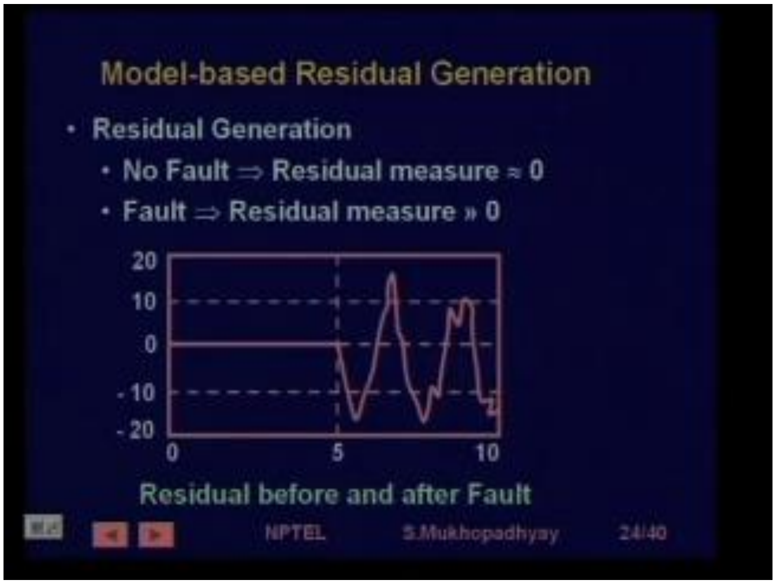
That they were not being they were not having enough number of heats similarly you can have equipment health or performance characteristics like you know you can have recon you can actually monitor machine tools whether they have got one out you can have fire brake linings check fire brake linings of furnaces similarly you can check monitor process operations like you know detect when you're pouring metal when slag is going to come or not and it is a trial etc so you can monitor various kinds of quantities.

(Refer Slide Time: 19:51)

So as I said that how to monitor a process you compare a process signal or some other signal derived from them with their expected or normal patterns so expected a normal pattern you have to calculate then how to obtain excited or normal patterns either by checking threshold high and low limits which you have already set or by checking material and energy balance error so for example if you know that the mass of material which is going out is subset of mass of fluid which is going in and the mass of food which is going out and not matching then there could be a leak in the equipment you can check certain parameters like heat transfer coefficients if a tube develop scales then the heat transfer coefficient is going to fall or you can also sometimes check sensor by physical redundancy you have more number of sensors so you check whether they're their readings are tallying.

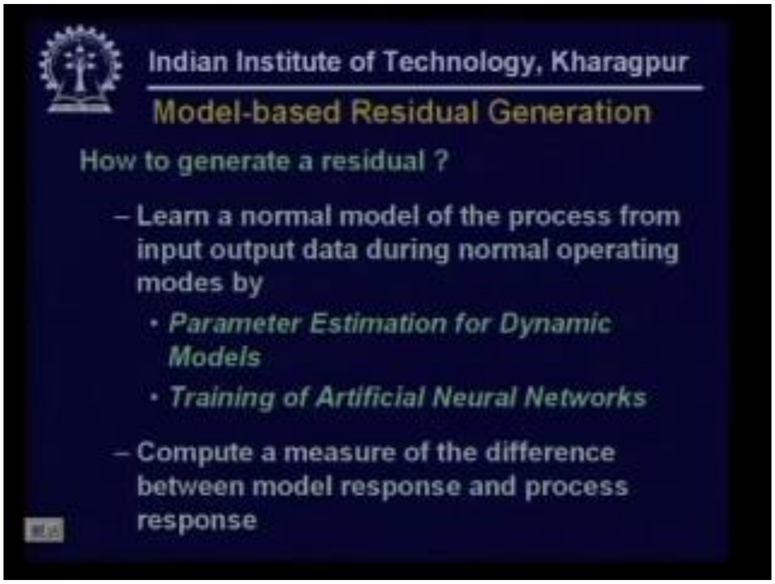
So you know that if one of them is not tallying then you know that that sensor is faulty so you can have several such ways of monitoring the process signals so you have you continuously look at the process signals which you're acquiring and then using various kinds of physical models or various kinds of experimental models which are mathematical once you can do computation which will which can tell you whether the behavior of the process is as expected in terms in terms of performance.

(Refer Slide Time: 21:23)



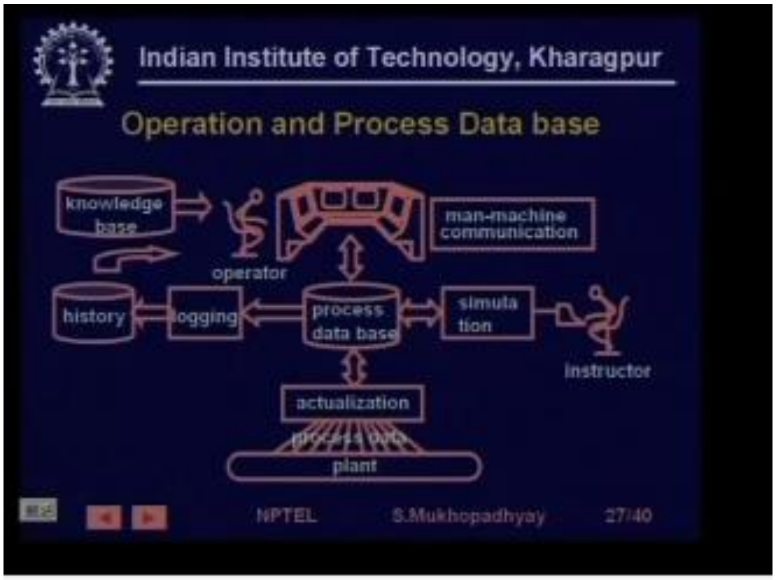
So I will skip this little bit this says that the residual signal model but residual should be calculated such that when there is no fault then the residual will be very small the moment there will be a failure this residual will grow up and so looking at the residual you can determine whether there is a failure in the plant.

(Refer Slide Time: 21:41)



So residuals can be generated by various ways various kinds of signal processing algorithms we do not have time to discuss the goals we will skip this.

(Refer Slide Time: 21:41)



And before I leave this level two so we were discussing level two and I'd like to say that all these you know both the optimization of set points as well as you know process monitoring require a lot of knowledge so you have to have good process databases and you and you also have a good knowledge base so that you can actually perform this computation so this operation and process data bases are very important components of supervisory control.

(Refer Slide Time: 22:27)

Now we come to level 3 automation basic functions are material and production tracking so how the production is actually taking place with respect to a certain order material handling and production procedures how the material will actually move from one machine to word to another machine what will be the sequence first milling then turning them boring or what so the actual production procedures then resource management and allocation how many machines you have which how many are you are you are going to allocate to what batches and what orders production dispatching.

So finally when you when you determine them then finally dispatching these to the lower level for actual production data collection and quality assurance so assured that from the from the from the data that you have got from the Supervisory control level as well as from the quality shop ensure that you are you are meeting quality standards which you have required and finally overall performance analysis the plant audits in terms of material consumption and energy consumption costs per unit call etcetera. So all these are typically done at the manufacturing automation levels document management.

(Refer Slide Time: 23:43)

Document management is a very important part of modern you know standards for all these things should always doing all these you have manufacturing execution systems which our computer systems which let you do all that so basically this is exactly what is being said that the manufacturing automation system this I also said earlier that the manufacturing automation system actually sits between the business system and the shop floor automation so it takes the business system requirements and targets and then generates in turn generates the targets which can be then sent over to the shop floor automation system which is going to actually meet those targets in terms of volume and quality and you know efficiency of production.

(Refer Slide Time: 24:28)

And that process is actually basically short term planning and scheduling so in short term plan planning you planning is something which you do in in the business system typically that is in level 4 and so you make choices with respect to order acceptance capacity planning delivery times at sites etc and then you take these short term plans and then you further augment them with actual production sequences production times root through the machines etc and then you also you know elaborate them you know kind of week by week day by day so they have much more detailed schedule.

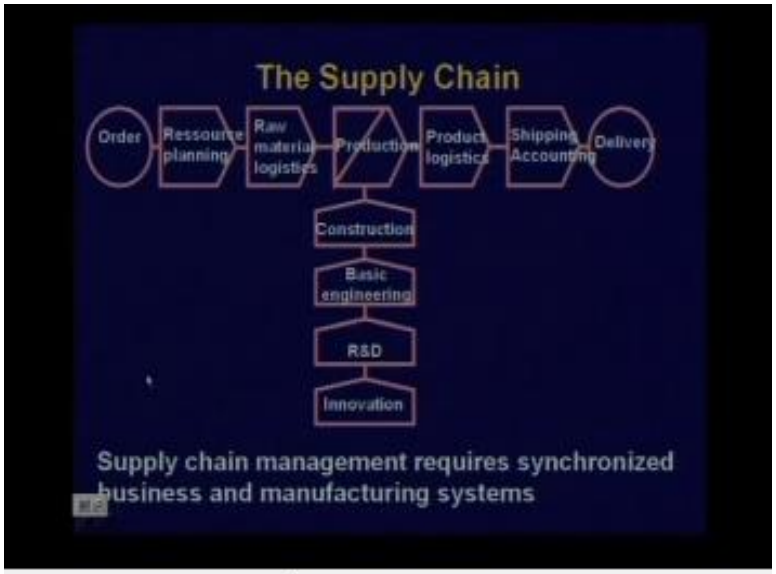
So these are the differences between basically scheduling is also planning but over a longer horizon and with respect to a with respect to the equipment which you are going to deploy.

(Refer Slide Time: 25:20)

So typically this is production scheduling so you determine you do you want to determine production amounts that means lots and batch sizes and you are given the planning horizon and the demands and in maintenance so how much is going to be required how much you can store over what time you should plan if you are given these then you product you plan the lot and batch sizes you can plan timings of operations the run lengths that is each set of batches how you are going to run them and that you need to you need that you can actually determine if you know the president's order in which the machining has to be done and the resource utilization.

So similarly you can determine this the how you are going to add at which sites you are going to produce these using which units which equipment items etc okay so this is what you essentially do in production scheduling now.

(Refer Slide Time: 26:15)



If you take a finely wheel we are going to take a we have to do we have to take a when we go to higher and higher then you have to take an integrated view of the of the business and that is sometimes modeled as the supply chain. So you have on one hand you have art we have the you have the orders and based on the orders you have to do resource planning and you have to actually make your raw material logistics that is how you are going to procure the materials that that you are going to transform to fine finish products similarly you have to have you know you have to create the facility for production which can come from you know RND basic engineering and then construction so you have to do capacity planning you have to do actually manufacturing resources you have to put together so once you bring the raw material and the and the manufacturing resources then you can actually do production.

Here you can do production so this is this is the place where you do production and then then once you have put the production then you have to your finally it has to start with the order and it has to end with the delivery right and all these all these DCS supervisory control actually work in only in this part there is the these parts are still managed by the enterprise or the or the business systems which take the product and finally ensure that the order to delivery sequence actually takes place.

So this is and obviously if you if you have if you manage want to manage the whole supply chain then it requires actually basic coordination between these systems which are you know sometimes called business systems busyness systems and these are the MES sand the DCS manufacturing execution system from the distribution control systems distributed control systems and these are the B2B systems so these systems obviously require synchronized business and manufacturing systems so the this is the essence of it that they have to be synchronized and they have to be integrated for ultimate coordination right.

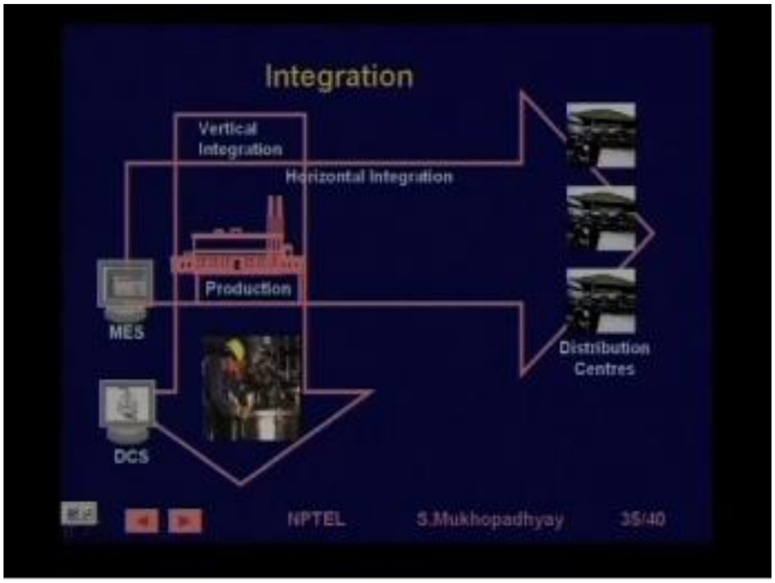
(Refer Slide Time: 28:45)

So that is why you need to so all these so as we have told we do not do not need to elaborate this that so the enterprise level system typically decides on the business parts long-term planning finance human resource and sets production goals capacity plans etc.

(Refer Slide Time: 29:01)

And this so basically they are they are also trying to do optimization they are also trying to do planning and so if you so at that level you do what is known as enterprise resource planning so and then these enterprise resource plans have to be finally taken up by the manufacturing execution plan and then actually the actually the man they have to optimize them so that you get the response so the ER system actually says that what kind of response is desired and the manufacturing execution system creates plans for lower level system such that such response can be generated right so then B2B obviously be very integrated.

(Refer Slide Time: 29:46)



Now this integration can actually be in both directions that is there can be vertical integration right from the you know enterprise systems down to the automatic supervisory control automatic control so that is vertical integration down to the machine that actually produces it and they also require horizontal integration in the sense that you need to integrate your activities over different sides between wire houses factory is right so that is special integration let us that's called horizontal integration. So you need integration on both sides we will skip these because we are running out of time.

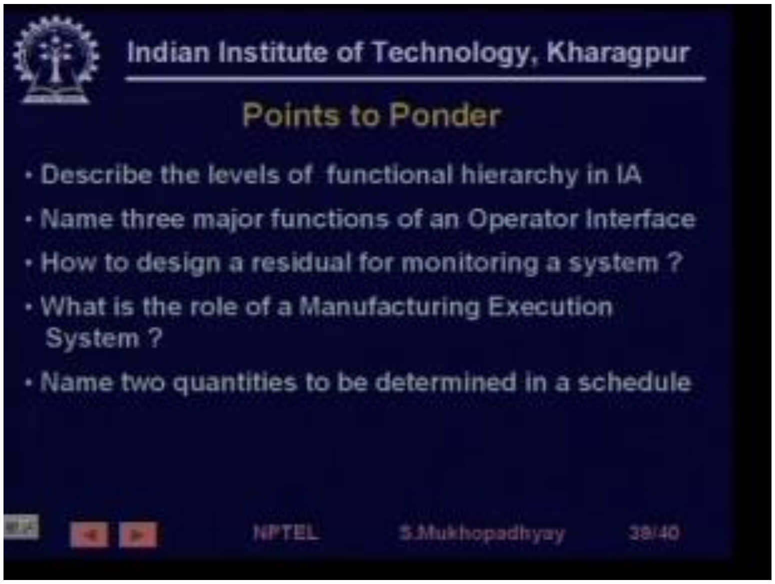
(Refer Slide Time: 30:25)

So finally I would like to just comment that for making all that happen you need actually a lot of intelligent automation and therefore you need a lot of deployment of industrial technologies.

(Refer Slide Time: 30:35)

Finally result lesson review so in this lesson we have talked about the basically d in brief we have tried to scan the three levels level 2 level 3 and level for automation.

(Refer Slide Time: 30:46)



And finally you have some points to ponder you can describe the levels of functional hierarchy name three major functions this basically described how to fill generate residuals etcetera so that is all for today thank you very much.