Chemical Process Control
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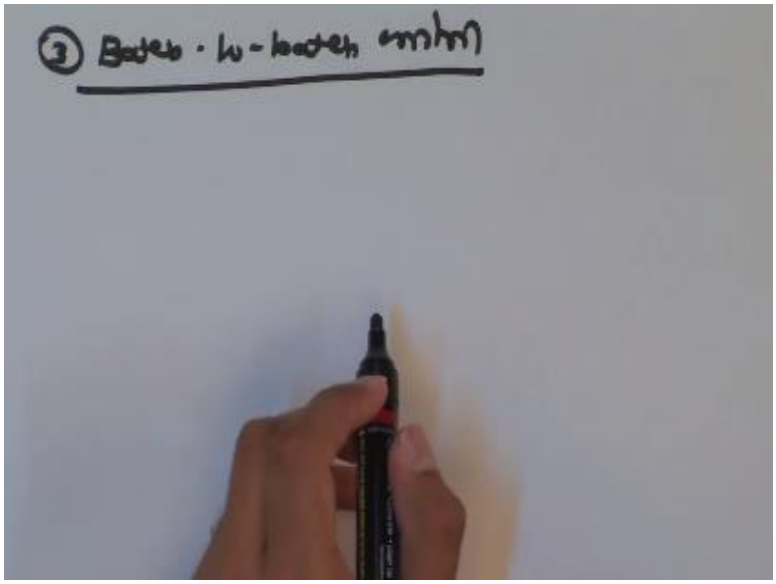
Lecture – 48
Batch to Batch Control

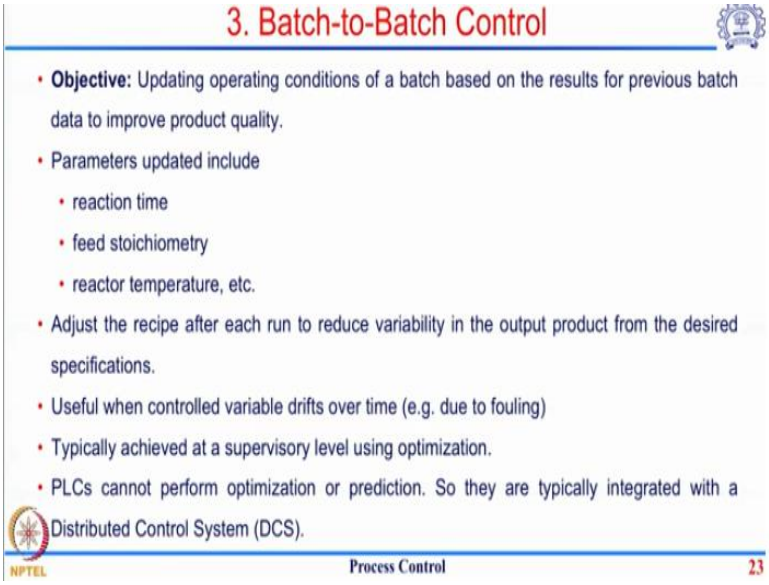
Okay, welcome back. We have been looking at batch process control and so far, we have seen 2 types of tasks which are performed in any batch process. The first one was sequential and logic control which ensures that the correct sequence of steps and the logic is implemented that moves the process from let us say a dry point to the operating point and then you have set of actions which maintain the operation along that point till the reaction, till the batch is over that is known as a within batch control. Now we will move on to the next step which is known as a batch to batch control.



Now in the within-batch control, I gave you one of the limitation or challenge in the batch process was that there is very little availability for manipulation in a batch process. You have fewer measurements within the batch and therefore there is very less amount of freedom available with you in order to improve the operation. But at the same time, it gives you an additional opportunity in the fact that you can learn from previous batches and then improve your next batch.

So, that is what is the objective of the batch to batch control. What it does, whatever the conditions of the previous batch and you receive a certain amount of product from that batch. It takes that all historical data which is available and as you conduct so many batches there is a lot of data which is available, and you learn from the previous batches so that your next batch gets improved.

That is the part of what is known as a batch to batch control. It is an advanced control strategy, and this will not be incorporated within PLC, but this is equivalent to the advanced control layer which we had for a continuous process as well. So what it does is? it updates the conditions for the next batch by learning from the previous batches.



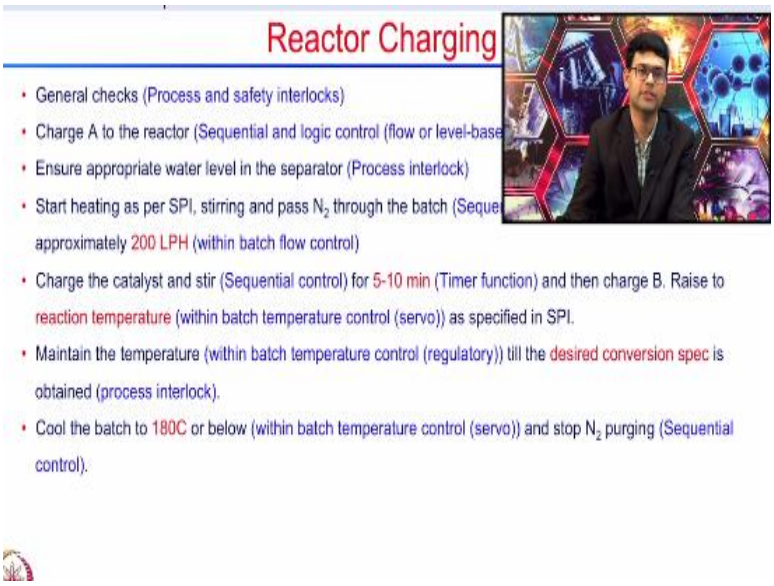
And what typically you would want to update are the time for the reaction, so this is like a batch time. Sometimes there is a stoichiometry which has to be updated. Previous batches if the excess air, let us say was 10% and the conversion was slightly less, the next batch may be operated at, let us say 11% as an excess air. So how do you go from 10 to 11 so that is based on all the previous data which was available?

From that, you develop correlation type of models or sort of a batch to batch variation model and all that based on that model, you will make some changes when you go from one batch to the

other. Another thing is, let us say the temperature at which the reaction is taking place, even that can be updated by using such kind of a batch to batch control strategy.

Then what you do is this all is done so that the variability of the process is minimized. What I mean is that you want to optimize certain performance and all that has to be done by change making some slight changes in terms of how the batches are conducted. This is also useful when the process itself changes as a function of time. Like if it is a catalytic process, then the catalyst may deactivate over time or if it is an exchanger, it may have some sort of fouling so the performance may change. The same reaction which earlier used to take 2 hours may now take 2 hours 10 minutes. All of that how do you go from that time of 2 hours to 2 or 10 minutes, so all those things would be dictated by this batch to batch control algorithm.

As I said earlier these are typically higher-level decisions. This is an advanced control layer and it will use most of these algorithms like iterative learning control, batch to batch control strategies. All those use optimizations and therefore they cannot be implemented using the PLC framework.



Let us now again go back to this real example which I was discussing and let us see where does this batch to batch control come into play? I have highlighted now some numbers here. Here what I am saying is pass nitrogen at approximately 200 liters per hour. Now that 200 number if I

change from 1 batch to the other, that will become part of the batch to batch control. Based on the previous batch data, you will try to predict what is the best value of that particular flow. Similarly, the timer function is 5 to 10 minutes, in reality, every batch would have a different value of this particular stirring and from the historical data, you will identify that let us say 8 minutes was an optimum time sufficient time to operate the batch. So from 1 batch to the other, you will change that particular time.

All those numbers or set points which were part of this within batch control all those are now sorts of the outputs of this batch to batch control. Again you can relate it to advance control advance process control and layer and regulatory control layer and what you can see that the set points for the regulatory level were given by the advanced control. It is a similar strategy here what you are doing is this batch to batch control is going to give you set points which are going to go to the within-batch control layer.

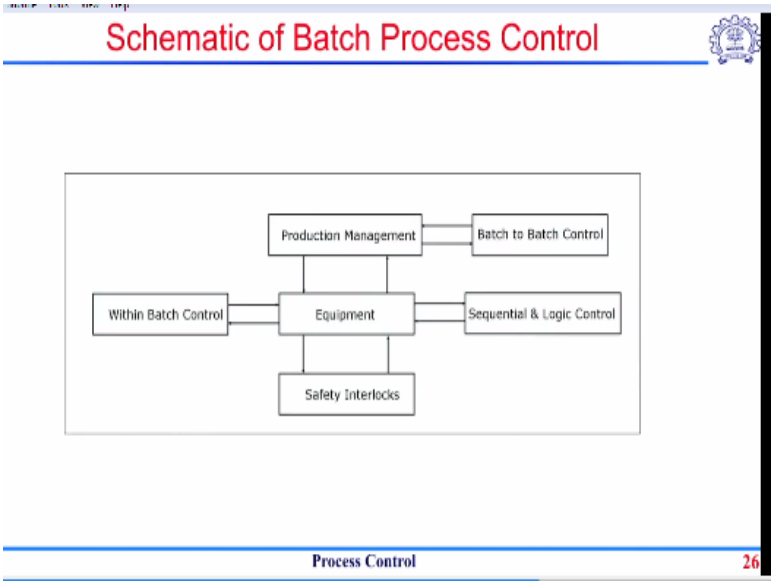
All these conversion specs that will also be part of that number. All these numbers would become the outputs of this batch to batch control strategy. So these numbers will be decided or change updated as we move from 1 batch to the other. So, that is about batch to batch control.

Lastly, in any batch process, any facility which has a batch process, there are a lot of different products, there are different product grades and there are different recipes. All those management

of that, you do not nowadays and typically rely on books having all these things. All this is incorporated into what is known as a batch production management. The different recipes are selected from that. So everything is within a piece of a computer and depending on what a batch what recipe you have to incorporate, you simply select that and then accordingly your sequence and logic control, the corresponding within batch control and batch to batch control would be triggered according to that. All this batch production management is more of a higher level management piece. There is no control per se here but all the scheduling related information would coordinate with this.

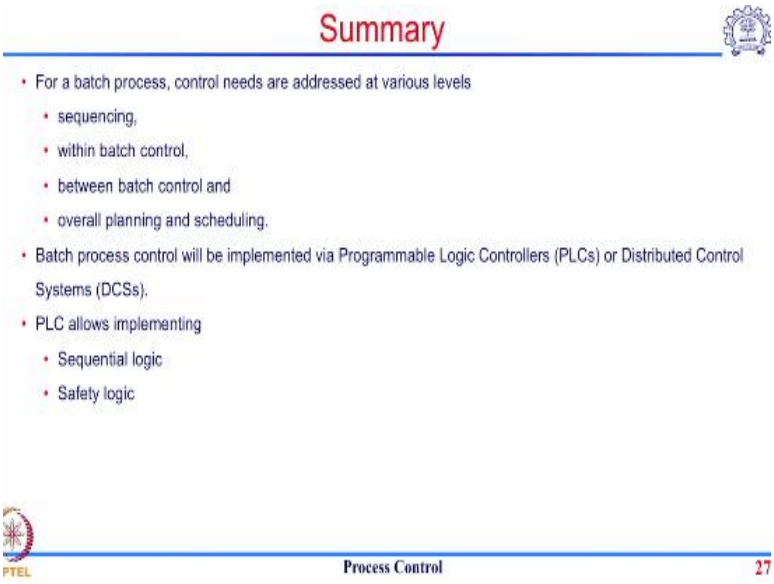
So that it will tell you first manufacture this much amount of product A, so the corresponding recipe will be downloaded, and every all the control action will be taken. After that, the schedule says that now you have to move from product A to product B, so again it will download that corresponding recipe to make product B. And then also those actions will be taken care of.

This is more like a higher level control which is going to maintain, or which is going to manage which different products are going to be made and all this if you really want to look into what are the different standards associated with batch process control, then there is an international society of automation ISA. The corresponding standard SP-88 is the standard which deals with batch process control. So these are all the different steps when it comes to batch process control.



If I want to really schematically show how this looks like, you can see that the equipment which is going to do the batch processing, it has a connection to sequential logic controls. Because that is going to decide how this equipment is going to operate. It also has safety interlocks even though I am showing it differently. It is part of this sequential and logic control. This safety interlocks here I am showing are more like a hardware interlock rather than incorporated within PLCs.

Then this equipment will interface with the production management because the production management will tell me which product has to be made, which recipe has to be followed. Once you have that equipment the sequence that for that particular recipe, you will have sequential logic control, you will have within batch control. All this will interface with the equipment.
The batch to batch control will not directly interface with the equipment. What it will do is, it will interact with whatever the data from the previous batches it is available in production management. And it will be based on that it will give or modify the recipe, so it may directly modify the recipe in production management, or this arrow can also go all the way to the within-batch control where it will change the set points to the within-batch control. So, that is how a batch process would be operated.



Just to summarize a within batch process control, there are 4 key tasks which you have to do. One is you have to do sequencing in terms of startup and shutdown. Then you have to maintain a certain condition when the batch runs that is within batch control. Then you learn from every batch to batch so all that data would be used in order to improve the next batch which is which becomes part of the batch to batch control.

Then lastly, what products to made how what products to make, how much to make, how do you transition from 1 product to the other, all that scheduling and planning related information will be as a part of batch production management. All that control the within-batch control and sequential and logic control will be incorporated using PLCs which are not programmable logic control. Then you will also have a DCS which is a distributed control system which will tie up then with this production management as well as a batch to batch control. So that puts an end to this batch process control, and this also ends this course Chemical Process Control.

I hope I was able to give you an overview as well as the motivation overview and sort of implementation about why process control is needed. What are the different gamuts of process control as well as dynamics and how it can be implemented for real systems? I hope you enjoyed this course and I will be happy to interact with you as the course runs. Thank you.