Plant wide Control of Chemical Processes
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Lecture - 29
Systematizing Plant wide Control Design

So, welcome to this next class. What are we going to do now? Well, right now we came up, last class we came up with some semblance of a procedure, that we have been implicitly imply applying to get to synthesize our control structures yeah. We want to refine it further and before refining it further, I would like to draw your attention to some aspects. What is the control system doing? If you think about it there are essentially there essentially two tasks, number one is stabilization.

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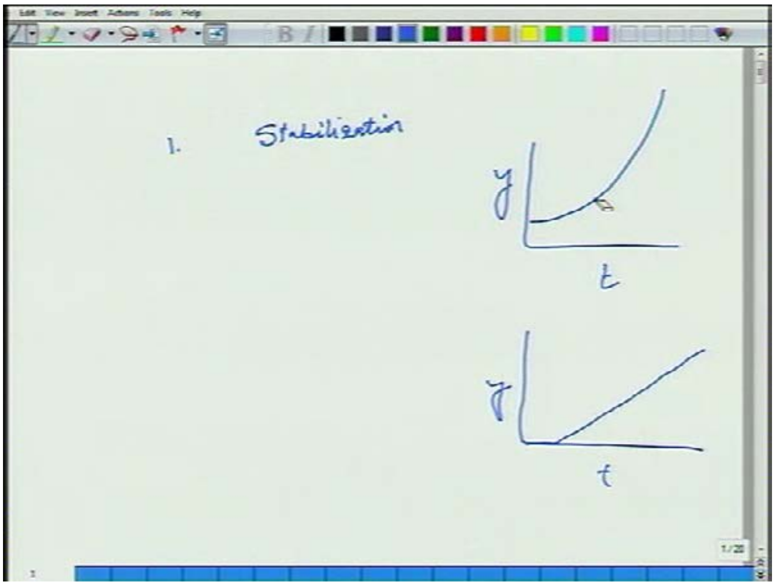

What do we mean by stabilization, what do you mean by stabilization? Something that is unstable needs to be stabilized. Yeah a missile is unstable you have to have a control system so that an aeroplane is fundamentally unstable unless we have appropriate control systems, only then will it fly in a stable way right. Exothermic reactors can be unstable, their temperature can run away, well you have to have a temperature controller. Levels are not unstable, but they are on the border of stability and instability. What is instability? If you look at instable and an unstable response output versus time, unstable response would you know low up something like this. Level or inventories in general behave something like, where y is a level you know, if there is a mismatch it either continues to build up or continues to deplete.

So, they are on the border of stability and instability. So, anything and everything that shows this behaviour, which behaves like an integrator or is inherently unstable you have to install a control controller or a control system to stabilize whatever is unstable in your process right, so there is this stabilization function. What is the next function?

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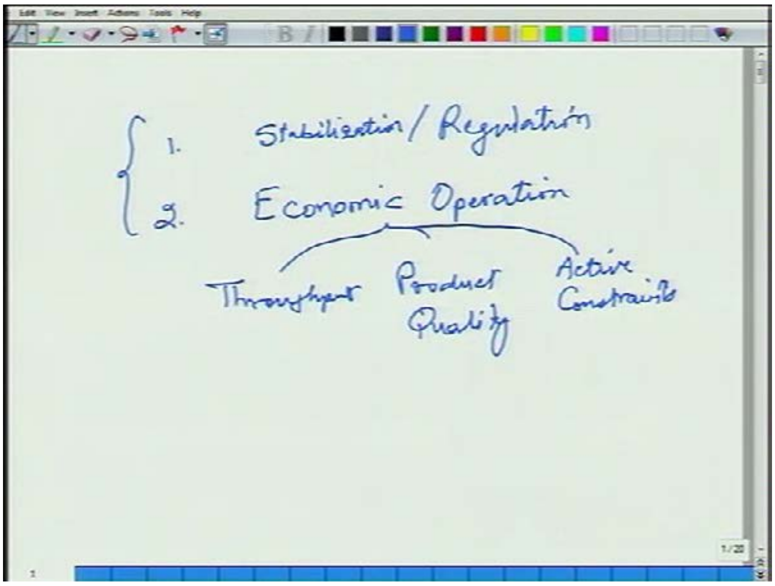

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Well, I was thinking of more, stabilization is a very general thing. So, something which is more general is what I am looking for. First you stabilise your process then you do run it in a way so that, it is what?

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It is as economical as can be. First function is stabilization, next function is what, economics. Economic operation, and economic operation could be in terms of, what, what is the throughput that you want.

Product quality that is desired what else, active constraints, you could also have things that are unconstraint. What do I mean by unconstraint? I think I need to qualify that a little more explain that a little more. But the basic point is your control system must be designed to first stabilise the process, and then ensure that whatever set points you are feeding it is ensuring in some sense economic operation.

What do you mean by economic operation? A you are producing as much as its desired, b you are producing only as pure a product as its desired not over purifying and not under purifying. Because under purified product would not sell, over purified will typically mean that you are selling something precious and not charging for it yeah.

And of course, we saw last time you know this column should be on flooding, this the other column should also be at flooding, well level should be max, temperature should be max etcetera, etcetera. So, there are these active constraints, you must design your control systems so that you can operate your process as close as possible and where possible at the constraint limit.

We saw this last time I hope you remember, but the general philosophical point is control system is doing these two tasks, stabilization oblique regulation let us call it. And when we say regulation that means, the inventories need to be regulated, every inventory whether it is gas or liquid needs to be regulated. So, process stabilization and regulation and then the next level is economic operation.

Now, what do I want to say next is now let us look at degrees of freedom. Every Process has got we discussed this more number of valves than steady state degrees of freedom. For example, the distillation column excluding the feed has got 5 valves 3 of those valves are used for pressure and two level and controlling for pressure control and controlling two levels that leaves you two valves which are your steady state degrees of freedom.

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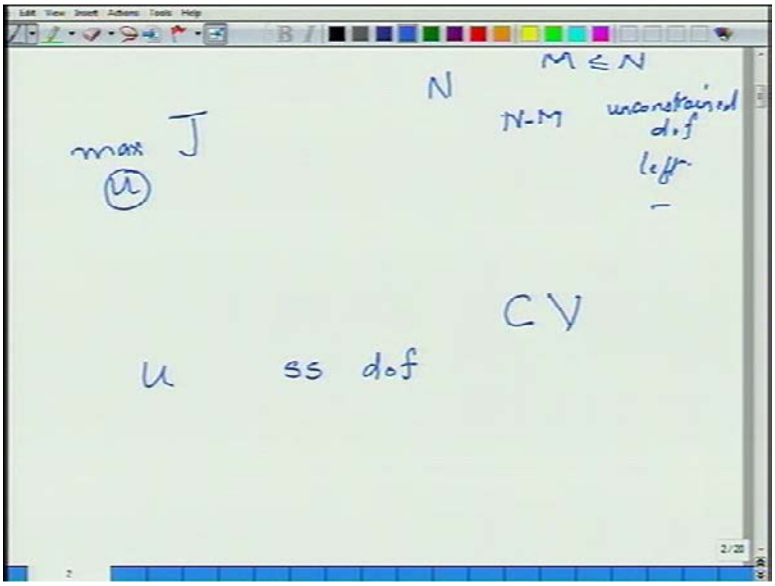

So now, when you are trying to optimize process operation, what you do is you have an you have some objective function J and let us say you are trying to maximise your objective function J and J could be for example, revenue earned by sale of product minus cost of raw materials minus cost of energy. So, that is your hourly operating profit right. It could be dollars or steam consumption per kg product produced.

It could be simply production rate, production rate of the value added product of your main product etcetera, etcetera. So, you want to maximise over your steady state degrees of freedom you are your steady state degrees of freedom and when you optimize you find let us say let us say there are N decision variables, of these N at the optimum there are M less than N constraints that are active, less than or equal to actually M could be equal to N and then there are N minus M unconstrained degrees of freedom that are left.

What I mean to says, if there are so many degrees of freedom, you want to drive product column to flooding, you want to drive recycle column to flooding, you want to drive reactor temperature to maximum, you want to drive the reactor level to maximum. So, that means, is four degrees of freedom are getting exhausted in order to make these constraints active. I am just taking from the example that we did last time, four degrees of freed get exhausted this way yeah whatever is left they are unconstrained degrees of freedom. Does that makes sense or not?

And there you need to think that well for example, composition. Let us see for example, I cannot think of something for that other process for example, let us say the reactor temperature cannot be kept at maximum, because if you take the reactor temperature too high, the activation of energy of the side reaction is much much more than the main reaction, your selectivity goes down tremendously.

So, even though you would like to maximise the temperature for greater conversion it turns out that you start producing so much junk at the at the maximum allowable reactor operating temperature, that you are better of holding the reactor at some lower temperature. If you reduce the temperature too much what happens, conversion goes down, conversion goes down then your recycle cost goes up.

So now, this is an unconstraint degree of freedom there is the low temperature limit and there is the high temperature limit, just by arguing about it, it is clear to me that I should not operate at the low temperature limit because my convey my recycle cost blows up. I should not operate at high temperature limit, because I am producing too much site product, my selectivity goes for a toss.

A good value of the temperature is somewhere in between, this high and low limit. There are These are unconstrained degree of freedom, where the exact best value needs to be figured out either by a model by an optimizer, or some good engineering sense. So, there are constraints that must be active, whatever is left is what those are your unconstrained degrees of freedom.

And now the question is, how what are those set points that I need to choose? I would like to bring your attention to something like this, see for example, let us say there is a 100 meter race. This is borrowed from see good see good (( )). If there is a 100 meter race what is your optimal running policy?

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Gas up you know just press the peddle as hard as you can at its limit run as fast as you can, that is your optimal operating policy for, what, a 100 meter race. Let us say it is a 40 kilometre marathon. Now, what is your optimal policy?

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Exactly. So, now now it is not so clear and you know and the and the and the route you supposed to take is not as flat. Sometimes there is down slopes, sometimes there is up slopes, sometimes you have to climb hills, sometimes you have to go downhill. So, now, your optimal policy is not so clear, but then you start thinking about it, what should I do, if I have to run a marathon race and I have to done it or I have to do it to minimise my race completion time so that I may win. What should I do? Everybody agrees running the fastest is not a good idea because I will I will simply drop dead.

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But then there is up hill and then there is downhill, if you try to maintain the same speed uphill, probably you will have your heart will collapse and when you are going downhill, if you still if you are breaking, then again that is not optimal right, you are unnecessarily slowing yourself down yes or no. So, may be what I should be doing is, you know these days you get those pulse meters or heart beat meters right or may be those calorie meters. So, may be you need to adjust your running speed.

So, that your heartbeat remains constant. How is that? That sounds more reasonable, right? now the only thing that the operator has to specify or the marathon runner has to figure out for himself is, what should be my what is my optimal level of my heartbeat right, if I maintain that for mild ups and downs, turns and twists, my running policy, my operating policy is, if not optimal at least near optimal. Does that makes sense or not?

So, what have I done? I just gave you an example what have I done.

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So, I am trying to choose a controlled variable. I am trying to choose a CV. So, there is an unconstrained degree of freedom that means, I can control one thing in my process. I want to figure out, what is that one thing that I need to control so that my operation is optimal. Does this make sense or not?

What is that one thing? See, if it is an active constraint then it is very clear, press the gas full peddle. If the column has to be operated at flooding limit, very simple operate it at flooding limit right. If the reactor has to be operated at maximum level, very simple operate it at maximum level right. It is in the case where you really do not know there is one trade of here or at this end and there is another trade of at that end. Low temperature conversion goes down dramatically, high temperature selectivity goes for a toss.

Somewhere in the middle is my optimal operating temperature right and this the value of this optimal operating temperature should not change by much, if I am changing my throughput, then it is a good CV. Because regardless of my throughput, regardless of disturbances, the optimal value of that set point remains close to whatever I am inputting. Does that make sense or not?

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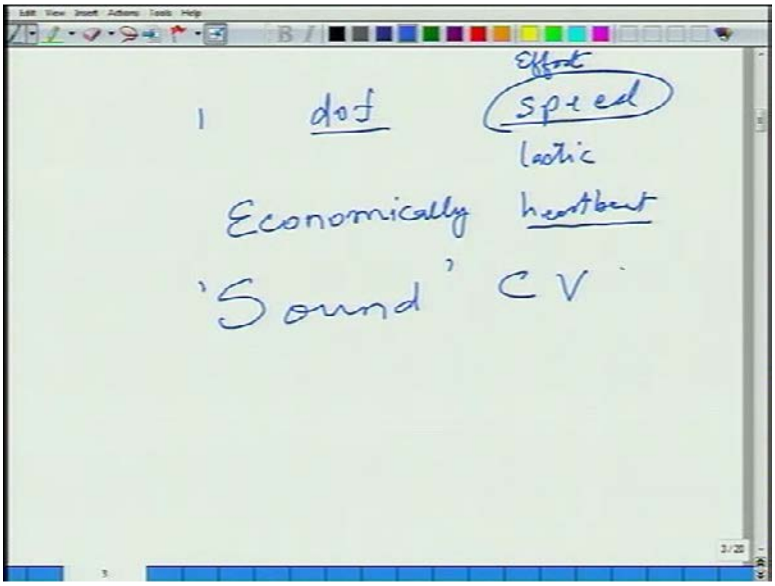

So, you see I have a let me explain it little more. I think this requires some elaboration, let us say there is one unconstrained one degree of freedom that I need to choose. In this marathon runner example, I had so many options. I could have controlled speed. I could have controlled I do not know level of lactic acid in my muscles, heartbeat, simplest thing to do is speed or speed or what effort. Effort is like the valve, how much effort you are putting in. The more effort you put in, the more speed you have.

So One fellow says maximise your effort. For marathon, that is not a good good policy because you do not have so much gas in you. Next fellow says, no adjust your effort so that your speed remains constant. Next fellow says, no you know there are ups and downs, certainly holding constant speed is not a good idea. When you are going uphill and holding the speed at the same value, when you are going downhill is definitely not a good idea. This is just common sense right.

So, next fellow says, no you know may be what you need to do is heartbeat. So, you adjust your effort to maintain the heartbeat constant. Then another fellow comes in says, where? You know, when you are fresh when you are fresh, your muscles are fresh, but as you run your muscles tired. And that degree of tiredness is indicated by the amount of, I do not know some chemicals that accumulates in your muscles which is miserable.

Let us say, lets I am saying lactic acid, it may be something else and I have a how much lactic acid is there in my muscles I know that. So, then what I need to do is, I need to reduce my heartbeat in order to maintain, what?

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lactic acid. Slowly but surely, I am maintaining something constant, but what is that something? that is not very obvious. It could be dumb, it could be a dumb choice. Dumb choice is maximise effort, that is as good as saying that, run and bloody collapse right. Of that is constant speed that is also a dumb choice. Heartbeat, reasonable, but it does not account for you know over 40 kilometre.You are going to tire you know, you can have a high heartbeat in the beginning because you are fresh that same heartbeat being maintained towards the 35 th kilometre is probable tiring you much more right

So, the moment you start thinking of this, so what is a sound controlled variable? And when I say sound, I mean economically sound. Now this is the question, the better your answer able to answer it, the better your operation. I cannot claim nobody can not me any nobody can claim that this is the best, you can always figure out CV’s that are better. The whole the whole idea is, for unconstrained degrees of freedom, what should I specify so that once I have specified it my operation is optimal here. Not only here, even if my throughput has change by 20 percent, it is still optimal or at least near optimal. Even if my throughput has decreased by twenty percent, it is still optimal, what is that variable, do you see what I am saying?

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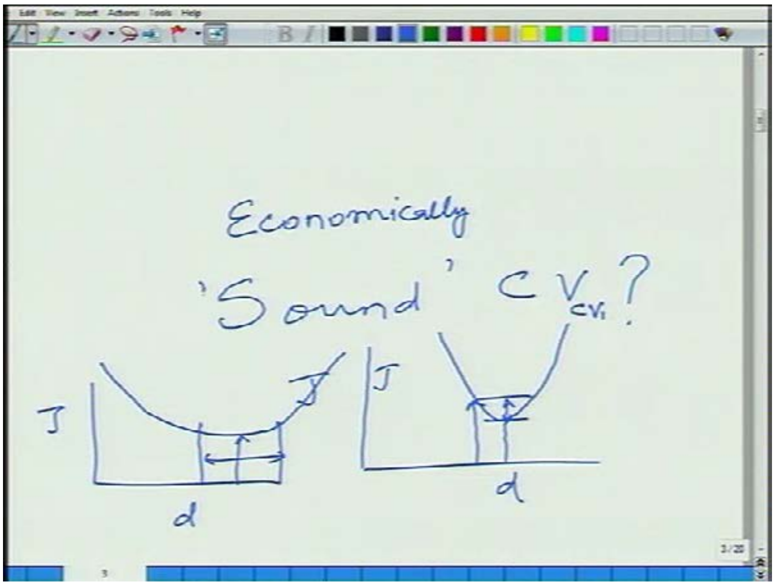

So, the whole idea is well you can you can draw it in a figure. Let us say, this is J, this is a disturbance my disturbance, could be a change in the throughput. My disturbance could be change in the impurities in the raw material whatever. I want to choose a CV. See you can choose any CV you want and you can optimize and figure out well for the given value of the disturbance. This is my If I am controlling CV 1, this is how J varies, well. Let us see this is not d this is CV.

So, the optimal value of my CV is this for some value of the disturbance. If you plot it against the disturbance what you really want is that no matter what the disturbance, the CV that I have chosen, each optimal value should be flat. That means, if my disturbance is this, as long as I have chosen the right set point for that CV. Even if my disturbance changes in this band my J is not getting affected by much.

Such a choice of a CV is a good choice for optimal operation, for economically sound operation. Such control variables would be referred to as economically sound controlled variables. And the whole idea is how to figure out these economically sound C V's and there is no what should I say the better the engineers the better is understanding of the process just like I walked you through that marathon runner example. The more you try to understand the process of running a marathon race, you will figure out that there is some policy that holding which constant is near optimal, if not optimal, near optimal.

If you talk to racers they will tell you, run like this conserve energy for the last burst and then the final thing is when should I take that burst. You see runners if you talk to runners, they will probably talk like this. When do I take that last burst and their whole mind is processing this, what should be my speed right now, others are overtaking me should I increase my speed, should I decrease my speed etcetera, etcetera, etcetera.

The point is we would like our control system to be simple. What do you mean by simple, just a second. So suppose, I had this situation, I was controlling a CV with respect to which my objective function shows a very sharp dip. If my objective function is showing a very sharp dip that means, if my disturbance changes by a small amount I am taking a big penalty. This penalty is an economic penalty. Yeah here I am trying to minimize J. I am not maximising J, but minimizing J. I want to operate at for example, minimum energy cost, negative of profit, negative of revenue something like that.

So, this is an economic loss. On the other hand, if I am controlling something with respect to which the optimum surface is very flat then what, that means, is if I deviate far away from here far away from if my disturbance moves this way or that way, I am still if not exactly optimal near optimal right.

And then my headache is over, why is my headache over? I just put in a control loop that tries to control that economically sound controlled variable by adjusting the valve that is unconstraint does that make sense or not? So, I just put that loop I input a set point and this set point need not be worried about, regardless of what my throughput is, what my feed composition is, regardless of the disturbances, the operating policy becomes very simple. It is it is simple to implement.

Do you see what I am saying yes or no, you see when you know that this column has to be operated at flooding limit or you know heater duty should be maximum. It is very simple to do that, just fire the heater just turn the gas full right, heater is running at max capacity. Small 100 meter race well, just put in as much effort as you are capable of right.

So, dealing with active constraints is actually straight forward, yeah it is this unconstraint degree of freedom dealing with that is, you know it can be made progressively better by understanding more and more about the process. Simple example that I gave you should convince you of that just is objective is minimized race time, marathon, what is the optimal policy, how should I vary my effort. So, that my clock time is minimized right

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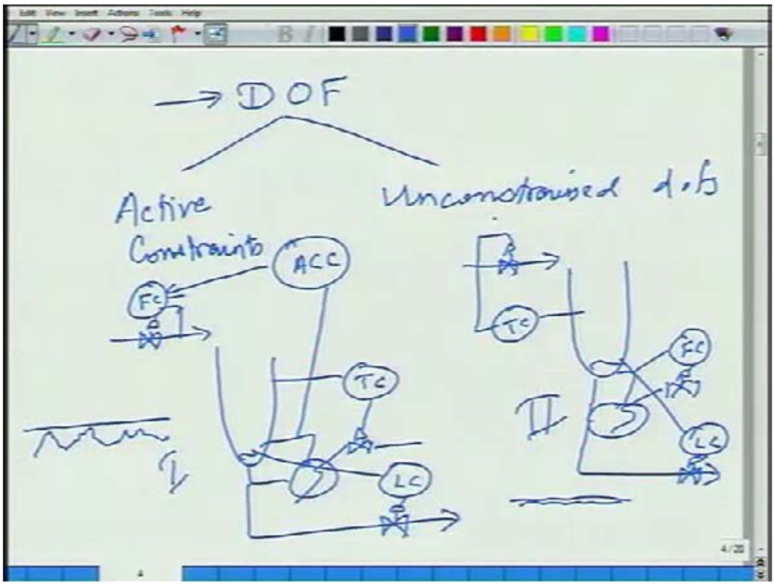

So, what are we talking about? We are talking about there are degrees of freedom, of these at the optimum, some will be active, the rest would be unconstraint. When you designing a control system, what do you need to do about active constraints? You need to make sure that those constraint variables well we will talk about this a little more you know active constraint means. So, if my gas pedal has to be maxed out you have to max it out. So, unconstraint degrees of DOF what do you need to do about unconstraint degrees of freedom? You need to figure out sound C V's, economically sound C V's, which are they? That is a question. That question remains. That question must be addressed by thinking about the process.

For active constraints, there are some rules of thumb. You want that your active, your column should be as close as possible to flooding or let us say you want boiler to be maximum. Now let us say, this is your column. I am just giving you an example to make a point. let us say what you have in place is a control system that does this conventional simple minded adjusts the steam to maintain a tray temperature so that lights of does not that is, what you would do if you do not think about constraints.

And let us say level control is, I do not know may be this way, now your analysis tells you that this column must be run at maximum boil up. If this column is to be run at maximum boil up, then what would you do? So, there is this feed that is the throughput manipulator. Now, since your steam is already under temperature control what you will do is, you will measure the boil up. If it is approaching maximum, then what will you do, you will adjust what you are putting in. You will reduce what you are putting in right. This I will call an active constraint controller.

To maintain the boil up at maximum, what I am doing is, I am adjusting the feed to the column. I give you an alternative and it will be obvious that the difference between these two alternatives would become obvious. So, there is the feed to the column what I do then is, I maintain the boil up by adjusting the steam. I do not use steam for temperature control. What I do is I do temperature control this way and of course, level control is as before.

Compare these two alternatives, where do you think you will get tighter boil up control and why? These are two alternatives doing the same thing. My analysis tells me I want boil up to be near max. If I want boil up to be near max, then what? Will scheme one, let us call this scheme one. Let us call this scheme two, which one do you think would be a better scheme, one or two? Just think the lag. If I make a change in the feed flow, what will happen to the boil up? You think it will respond immediately? What is, if I make a change in the steam? Response of boil up will be faster to which one in the second case.

So, I change the steam boil up responds immediately. I change the feed, what happens is temperature cools down or increases in response to that the temperature controller adjusts the steam, in response to that the boil up changes. You see there is this additional lag associated with the temperature having to respond to the change in the feed before the boil up change.

Yes or no yeah that being the case, I can look at this scheme and say that with reasonable certainty that look, if you want tight boil up control then this is the better option. Option two is the better one, because you are directly controlling the constraint variable with a handle which is closed by, with the manipulation handle with the valve that is closed by. What are you doing here? Your manipulation handle is a far away, further away. If not far away, it is further away than right and therefore your control, your dynamics are slower.

If your dynamics are slower, your control cannot be as tight. If your control cannot be as tight, what you will find is, that the boil up is actually varying like this and therefore, you cannot, you see if this 100 percent limit, you will have to operate like this. In this case because the steam is right there, there will be some variability in the steam, but it will be very small.

Flow control will be very tight right. If the flow control is going to be tight, well you are almost at 100 percent level, yes or no does that make sense or no. So, this scheme will allow me to operate closer to the max boil up limit, which comes from the flooding limit compared to scheme one, yes or no yeah. So, what am I trying to say, you active constrains need to be controlled as tight as possible yeah. You want to minimize the back off. For tight control, what do you need? You need a manipulation handle that is as close as possible. yes or no.

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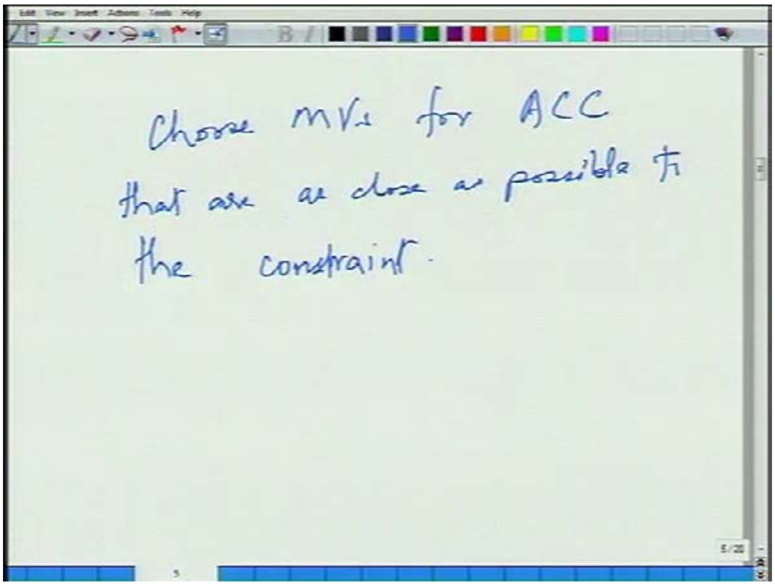

So, for tight active constraints rule of thumb is, choose manipulated variables for active constraint control that are as close as possible to the not the CV constraint to the constraint, does this makes sense or not? These are just simple minded things have taken a long time to explain this, but when we start looking at processes, you know what should I do? Where should my throughput manipulator be? Should I control their the column temperature using the steam or should I control it using the feed or may be should I control it using the reflux or should I not even control it, yeah.

These things need to be kept in mind, when you are designing a when you are designing a control system for a complex process, with prior knowledge of what are the constraints that are active. Then you know that process may not be feasible economically to begin with. Second thing you need is, whatever you are selling must command a premium. For example, if the government brings in a regulation that says this additive cannot be added to petrol. You have a plant that is running to making that additive. Government has banned it that is it, that process is dead, you see what I am saying.

So, some basic things need to be satisfied. Energy is much cheaper than petrol or be benzene or acetic acid or whatever, per kg cost. Whatever you are producing, should be much more, not if not much more at least 20 percent, 30 percent more price per kg than what you are putting in the raw material. Unless these things are met, it does not make sense to have that process, right.

What is your question? Firstly, last to last to last to last when we did this we wanted to go for first screen, because throughput was the main thing we needed to control. yeah So, through no just a second, so throughput when maximizing throughput makes sense economically? When there is sufficient demand, but not too much supply, for example, there is a new market that is opening up. You found a technology, nobody else can make that, you have a patent for it. There is sufficient demand in the market, for example, PET you know, this coca cola bottles, eastern chemical makes it, when they came in they were the only manufactures.

So, their whole idea was make as much as you want, because there are N number of guys who will take it, at whatever price we want. If I want to make money, that is the way to make money. Just maximize your production. Competitors caught up 2 years 3 years down the line, but for those 2, 3 years your policy was jack it up. The moment the competitor came in, well your price went down. Immediately, its same thing happens in shops there is one guy in shopping centre, he says you want to take it, take it otherwise buzz off.

Today we have mahir and supers and now both behave very well. I will give you five rupees off this juice packet, that fellow gives seven rupees off this juice packet; you see how fragile economics is yes or no. So, when we are saying maximize production I guarantee you, it will never be true that for this process maximizing production is always optimal through the whole life of that plant, no. May be for a year when the competitors are trying to catch up.

The moment competition comes in, then you have to move like a cartel. Boss does not glut the market, you are also going to get screwed, I am also going to get screwed. Do not produce too much tomato. We have to make sure that the pricing remain, such that do you see what I am saying we do not kill each other, then it becomes a cartel. If you are first in the market, maximizing production makes sense.

The moment competition comes in, then you need to have some sort of understanding at some level, that look we should not kill each other by glutting the market yes or no. So, that is why I even though I said J is for example, raw material price minus this, I am not very comfortable with that. Why I am not very comfortable with that? Because prices are very fragile.

One war in Libya and then that is it, one government regulation then that is it. One standard and poor rating goes this way that is it, is. These things are too fragile, yes or no. So, but the point is, you need to still think it out. If my product is commanding a premium, compared to my raw material and if it makes if there is sufficient demand even though there is competition, it will definitely pay you to think, what is the best way of running my process?

Regardless of the economic scenario, economic scenario can change, such that raw material is more expensive than the product well, then plant has to be shut down as simple as that or may be a catalyst who has got invented or may be there is a market that came up which was commanding so much more premium for the for the product that there cumin, earlier it used to go to nylon. Now most of it goes to phenol resins, you know those gums and adhesives you know.

So, production capacity is what it is, that the downstream product mix has changed you see what I am saying. So, the point is J is equal to product minus raw material minus energy that is very fine, but how the hell do you predict? How the hell do you guarantee the stability of those product prices and raw material prices, etcetera, etcetera, etcetera, nobody can.

So, therefore, economics rise and fall and that uncertainty I do not think you can do anything about it, its fine and handy to talk about it. Look this was my objective function, this is the price I assumed, I put it into an optimizer, this is the result that it gave, these are the active constraints. These are unconstraint degrees of freedom, as a systematic way of understanding the process that is fine. But I still do not think, I am still not convinced, that that is the best way of running the process.

How much to produce, what quality to produce? That is best left to market analyst, who will say look, who will do their understanding with their cartel players etcetera, etcetera and say look your plant for the next two months production objective is, so much of product, this quality, this product mix. Winter season is coming heating, heating oil demand is going to go up, gasoline demand therefore, jack down the gasoline that you are producing, jack up the heating oil because winter season is coming right.

Basically objective function has. So, we have (( )) Yeah. So, the my concern with this approach is, the objective function itself is quite fragile, if it is based purely on prices. So, what I prefer in my in my thinking is, some economist should tell me, what to produce, how much to produce, then I Can do it in a way that, economist can also tell me produce as much as much as you can because we are the only produce. We have a monopoly over the market for the next 2 years, because this is our patent for the next five years even to copy it will take two years right fair enough.

But then I am told maximize production. if an idiot like me comes this is the price this is this what is the best thing? Always the answer will be maximize production and if idiots like me are there in every company they will all maximize production nobody will buy it or warehouses will get filled up with the products. We will not be able to sell it. We will be paying guys and everybody will kill each other, do you see what I am saying.

So, do not swear by economics. I do not swear by economics, but certainly what is the most efficient way? How should I run this process, so that, for so that for this production rate or for this throughput my energy consumption is minimized. Certainly as an engineer, I can I can figure out yeah reactor level should be highest because the conversion is maximum therefore, amount to be recycled is minimum therefore, the amount of steam required to recycle the unreacted reactant is minimum.

This will be true, whether I am operating at 100 kilo moles per hour production rate or 150 kilo moles per hour production rate yes or no. So, it is an active constraint came comes out purely by engineering common sense. Well I need to run my reactor at maximum a composition because if the if the a is a composition is high b composition is less, side reaction is therefore less because the reaction chemistry dictates that the reactor should be operated with b limiting because if b becomes too much too much site product gets formed.

How do I maximize a recycle? By maximizing my boil up because whatever I am boiling up minus the reflux, is what is getting recycled right. Now weather my production rate is 100, 120, 150 this thing is going to be true, regardless of the economic situation as long as my product is desirable this is what I should be doing. So, reactor level should be max, column recycle column should be operated at max boil up or flooding limit. Depending on the kinetics, I may also say that the reactor should also be operated at the maximum temperature, because the kinetics are such that jacking up the temperature has only a very marginal effect on selectivity, right which I am able to overcome by ensuring maximum access ratio right.

So, then I have got three constraints active maximum level, maximum temperature, flooding limit on the recycle column this has come purely by what applying engineering common sense. I repeat this again, it is very easy today to formulate a problem. Some objective function, a set of constraints submit into a optimizer, it will spit out some results this and this is active.

The whole thing is meaningless unless you try and interpret why the hell is this active? Why is the hell is the my optimizer saying maximum level? Why the hell is my optimizer saying maximum boil up? Why the hell is my optimizer saying this or that? Why the hell is this unconstraint? If it is unconstraint means that there is some trade off. At this limit something would be happening, at the other limit something else would be happening. Somewhere in the in between is the optimum, right.

Trying to understand this will make you a better and better engineer. If you do not try to understand this, you can do N number of optimizations. You will remain a fool came in a fool went out a fool a fool can still came that oh. I did not have the benefit of an optimizer. You cannot even claim that, do you see what I am saying. So, what the hell was I saying, choose M V'S for active constraint control that are as close as possible to the constraint. More fundamental than this, try and interpret why is the constraint active? Why does it make economic sense, to have the reactor at max level, temperature at max, this column at its flooding limit etcetera, etcetera. That I am assuming anybody, who does the optimization would do this before recommending implement this as your plant operating policy right.

So, there are active constraints and the rule of thumb for those active constraints is, well if the constraint is active you want tight control of that constraint and therefore, for tight control you need a manipulated variable that is close by. So, that the dynamic of that loop is fast. So, that it could not be tuned to be really tight. So that, the variability in the constraint variable is small, if the variability is small, you can op you can operate closer to the constraint limit, back off would be smaller. So, this minimizes back off right done.

So, handling active constraints makes things very simple. These are active constraints, this need to be controlled tight. What is the nearest MV that is available for controlling this active constraint, well that is what needs to be implemented, yeah. Unconstraint degrees of freedom, I spent a lot of time time trying to explain to you that look, in order to have a simple control system the dirtiest approach is, well for every disturbance I will reoptimize.

So, today my production rate is 100 kilo moles an hour. Let us say, my unconstraint degree of freedom is reactor temperature for the sake of it. Today my production rate is 100 kilo moles an hour, optimal reactor temperature from a model by an optimizer run blindly comes out to be x. Tomorrow my production rate is 130, it comes out to be x plus I do not know x plus may be a. I can keep doing my optimization again and again and calculating the optimal value of the reactor, my unconstraint degree of freedom that is one way of doing it.

Problem is, it is not simple. It depends on the fidelity of your model etcetera etcetera For example, you may find that instead of controlling the reactor inlet temperature or reactor temperature, you are better of for example, controlling the inlet temperature minus outlet temperature that comes out to be nearly constant, whether the throughput is this or that or that, does that makes sense or not.

So, now, you are saying instead of controlling reactor t may be we should control reactor delta t because it is what self optimizing, plus holding this constant is economically sound right. So, this is the idea of self optimizing CV's much thought needs to go into how I select my unconstraint? What CV is selected for handling unconstrained degrees of freedom and this is what distinguishes good engineers from bad ones. This is what distinguishes wise guys from the fools.

A good engineer will be able to tell you, well instead of controlling this, why do not you control this? This will work not only at this disturbance value, this will may reasonable even at this disturbance value. This is it is insensitive to the disturbance right. That is the whole idea of you know that is what distinguishes a good operator from a bad one, a good control system from a bad one, a good engineer from a bad one.