PODCAST EPISODE TRANSCRIPTION

Episode Summary:

In this part one-of-two episodes Jim Jacoby (Senior VP of Technology at Tri-Sen), Tyson Johncock (VP of Engineering and Service), and Tom Bailey discuss compressor [control] surge margin.

Tom:
Hi and welcome to the Turbomachinery Controls Podcast where we'll be informally discussing turbomachinery controls and turbine safety related questions and topics. Opinions expressed here are our own and not necessarily those of TRI-SEN.

I'm Tom and I'm with Jim Jacoby, senior vice president of technology here at TRI-SEN.

Jim:
Hey, Tom.

Tom:
And Tyson Johncock, vice president of engineering and services here at TRI-SEN.

Tyson:
Good to see you, Tom.

Tom:
Good to see you, too, Tyson.

In this episode, we'll be talking about Compressor Surge Margin. Specifically, what exactly we mean when we start talking about Surge Margin? Also, what are the variations of Surge Margin? And then, how do you determine what the Surge Margin settings should be?

Okay. So, let us start with the first question. What exactly is Surge Margin?

Jim:
Alrighty. Well, probably… a better term to use for it would be the set point of the surge controller. But when we talk about margin in this business, we are talking about how close you allow the operation of the machine to get to the surge line and that's effectively the set point of the PID that's trying to maintain that distance to the surge line.

Tyson:
Yeah, I agree. That's …yeah, margin. I have never liked margin, right? I mean, margin for error or margin for what? But for me, it's the controller. It's the set point. So, when you talk about a set point and a controller, people kind of register, "Okay. That's the place that this controller wants to take action."

Tom:
Yeah. And I guess it's just in context, though, right? In context to the surge lin…or this place that's close to the surge line.

Tyson:
Yeah. So, you are asking what is the margin... It's the set point. It's the distance you want to stay away from surge. The distance you can stay away from surge.

Jim:
I hear customers asked the question how much margin… "What's your margin?" And that… …they're not talking about the set point. They're talking about how far the operating point is from the surge line. So, in the business, I guess when they start talking about margin for the controller, they're really talking about the set point.

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Tom:
Yeah. Visually, when I think about it, though, I always think about this space; that's defined… …there's a left side which is the surge line and then there is this place where you start doing something if you cross it. Like, there's this boundary if you will.

Jim:
Right.

Tom:
But it makes sense, you guys do it all the time, and so, you're saying that, really, when you are talking about a Surge Margin it's a single point in space. The thing is, when we talk about it in general, we're talking about it in relation to something else because ten percent doesn't mean anything, right? I mean, it literally doesn't… It means…because that's not a flow and it's not a pressure ratio.

Jim:
Yeah.

Tom:
Are there variants [variations], for this surge control set point or surge control margin?

Jim:
I think there is probably two basic ways that you fashion a set point line or curve. And the most common one in my experience has been based on a constant offset. And that's because you have your [anti-surge] control system that's typically based on the flow range for your flow transmitter. So, you are working everything based on a percentage of that flow range.

The other way is proportional to the surge line. So, if you said I want a ten percent margin based on the surge flow, well, then the higher the pressure ratio is, the more that surge limit line bends over the greater the amount of flow range you are going to be taking for that margin.

And that proportional [setting], to the surge line is the one that compressor manufacturers will typically specify because they don't know what the flow range is going to be. So, they just say, "Well, I don't want you to get any closer than ten percent away from my surge limit line based on that search flow." And that's where that comes from. And, well, I guess you can combine them, too, right, Tyson?

Tyson:
Yeah. It's a hybrid line. So, some mixture of it. I mean, the envelope of the compressor with a choke or stonewall line at really low speeds and low flows or the lower guide vanes, you don't have much of an envelope to move around in anyways. So, you can start with a smaller set point in those low ranges. And as your envelope starts to open-up, you can give the search controller more room to move.

And then once you get enough in there that it's protected, you don't need to increase it anymore. So, you put sort of a max limit or a clamp on a proportional line. So, it's increasing as your pressure ratio goes up till it reaches, say, ten or whatever the number happens to be. And you say, "Okay. That's enough to protect the compressor." It does not need to turn into twenty at the high-pressure ratios because there is enough response in the system to protect [the compressor].

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Tom:
Yeah. Sure. So, does it vary for you depending upon the application? Are there some applications that you guys always go constant margin...or for types of compressors?

Tyson:
For me, typically it's axial compressors that have a really tight envelope on the lower pressure ratios. You will see proportional lines and then usually proportional with some constant. Once you get to that place that has enough area and you don't need to continue to increase [the margin].

Jim:
The few times that I have seen a benefit to having the proportional offset was when the mole weight varied a lot for the machine. In that case, the customer wanted… when they were running at the lower mole weights—that was [at a] lower pressure ratio and they needed to get closer to the surge line—they needed that capacity.

But when they were running on the high mole weight cases, they were running way out on the operating envelope. So, using a proportional offset gave them normal protection at the higher mole weight. But when they run [at a] low mole weight, it allowed them to get closer without recycle.

Tom:
And just to be clear here, really, very quickly, the surge line is invariant to this mole weight, right?

Jim:
Right.

Their process needed more room at when they were running at the low mole weights. The envelope shrinks, right?

Tom:
So…

Tyson:
You asked [about] the margin. You didn't say surge curve.

Tom:
Yeah. You are so aggressive, Tyson. I want to put that out. No, I… yeah… I…

Tyson:
So, it's…

Tom:
No, what I am getting at…

Tyson:
Just stay on target.

Tom:
Yeah....One of the things is I want to make sure that we are not getting lost here is this universal surge curve because it's easy for someone to say, "Wait a minute. You are talking about mole weight now, right?" That does something. That's all.

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Jim:
This was not that they needed a whole lot of extra margin at the higher mole weights. But because the whole compressor envelope shrinks so much, they needed that extra range. The process machines we typically work with don't have huge mole weight variations and the pressure ratios don't change that much. So, a constant offset is just a simpler implementation.

Tom:
So, does it matter if it's a multi-stage compressor or single stage compressor? Does that enter into your calculus as to what type of margin or set point you use?

Tyson:
Not for me.

Jim:
I can't think of a time when that that affected it. Of course, you have a much more complicated surge limit line when you have a multi-stage machine, right? You get multiple---

Tyson:
I will go out on a limb and say… I mean, I don't think I can remember any centrifugal machines that had proportional lines. Seems like most of the actual machines that I have done had some proportional component of it. And, I mean, that was pretty straightforward. I think it's because of the shape of the envelope on the axial machines that people look at it and say, if you put a constant ten in there, you are cutting off a quarter of the curve on the low operating range.

And so, you try to put the proportional in there to give them some access to that part of the envelope without the vent valve just staying wide open.

Tom:
Right. Okay. So, I need you to say something again. For a minute there, I think you said—I could be wrong,—but…

Tyson:
I'm not sure I can say it again.

Tom:
Something close to it… I think you said, though, that a centrifugal compressor has a proportional part of it. And I think that's not what you said.

Tyson:
No. I was saying that…constant on centrifugal…proportional on axial.

I can't think of a centrifugal compressor that we really put proportional on. We always put constant on. And so, the axial machines mostly have proportional with, maybe a limit on it. So, I would consider a lot of those to have a hybrid, some sort of a proportional line starting and then when it reaches enough margin to protect the machine and you clamp it as a constant.

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Tom:
So, I guess that leads into the last question here or the third question, maybe. How do you pick a number for the surge control set point, surge control margin, whatever we are going to call it?

Jim:
I think the starting number is always ten percent. And that it just… that seems like an easy number for everybody to work with, but, after that, it's... you got to…

Tyson:
Ten is sort of everybody's number. Ten percent of what, that's debatable…

Tom:
That's what I want to ask you, let us not debate it. Tell me what you… ten percent of what?

Tyson:
For me, the applications we are working on, most of the time we are talking about ten percent of the range of our map. But if you talk to some other people, they're looking at ten percent of whatever the surge line range was. So, ten percent of the surge limit or the surge curve line, saying "give me another ten percent of whatever that value is." But once we have transmitter ranges, we have sort of normalized our surge curve to some percentage of that flow. And then we are saying ten percent of that map which is the curve that's on that map.

So, for me, ten percent of a hundred is what that's.

Jim:
But that's going to be a much bigger flow range than ten percent of the surge line flow.

Tyson:
And it varies because if somebody has picked a really high normalizing factor for the curve, you have pretty much a vertical surge curve so that ten percent on that map is a lot; whereas, if somebody has picked a smaller flow range and normalize their curve or where the surge curve is more leaned over, that ten percent might actually be getting closer to what ten percent of the surge curve is. It's not going to be but you are starting to come back to that. So, it's relative to the range that you normalize your surge curve to.

Tom:
Right. So, let's say that—just for fun—picking a number, let's say, that your surge point for whatever the speed is, …

Jim:
At a given pressure ratio…

Tom:
…at a given pressure ratio— is fifteen percent and what we are saying is what we would set the surge control set point at twenty-five percent.

Tyson:
That's correct.

Jim:
That's right. But if you said ten percent of the surge point flow, then your set point is going to be at sixteen-and-a-half.

Tom:
That's right. .

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Jim:
That's pretty tight. That's not a lot of room to work with.

Tom:
Yeah. That's one-and-a-half percent, right, of flow.

Jim:
Right.

Tom:
And then is that in the noise range for you guys? Typically, what kind of percentage of noise do you…

Tyson:
I would have questioned the surge point at fifteen. So…

Tom:
That was an example…

Tyson:
Yeah, but I'm…

Tom:
...it's easy math.

Tyson:
But I'm…

Tom:
Okay…

Tyson:
...but I'm saying…

Tom:
…go ahead. Make it harder math.

Tyson:
...but I'm saying, probably, what the curve was normalized against was probably too big a number. And so, that surge curve maybe should have been thirty-five.

Jim:
Okay.

Tyson:
And then…

Jim:
Use that number.

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Tyson:
So, now we're talking three point five which is still less than ten, but you could see that they're starting to converge.

What I want to say is that it's… it really needs to be that you normalize your curve on a good number. You don't want to have a very vertical surge curve that's way over at five percent.

Jim:
But you are always going to have a much smaller number based on a percentage of the surge line.

Tyson:
Oh, yes.

Tom:
It went from fifteen to thirty which is good [easy] math. And so, we double that from one-and-a-half to three, right? So, it doubles everything.

Tyson:
Yeah.

Jim:
And that's probably a good example of why if you are going to use a proportional offset, you would probably have some constant added in there because at lower pressure ratios you are going to get really close to the line.

Tom:
...and we're going to call it a day here and we'll continue this conversation in our next episode.

Drop us an email at turbomachinerycontrols@tri-sen.com. Let us know what you got on your mind. Thanks for listening and we'll see you next time.

[END]

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