Analyze That episode transcript

Comparing XRF Technologies: What Matters for Slurry Analysis?

Hello, and welcome to another episode of Analyze That by Thermo Fisher Scientific. I'm Kevin Gordon. I'll be your host today for this podcast. And we're joined again by Tom Strombotne.

So this is part two of our conversation. We recently just talked about the MEP-400 - Thermo Fisher Scientific has just released a new product into the industry. And we've got Tom back here again. Thanks, Tom.

Hey, Kevin. Nice to see you again.

We had a great conversation about the MEP-400 recently, and you had talked a lot about EDXRF. Well, there's also WDXRF. So I think it would be interesting to understand from a high level, at least at first, what were those key differences between EDXRF and WDXRF, and how do they work differently within the process?

Sure. So just to start at the real basics. EDXRF is energy dispersive X-ray fluorescence. WDX is wavelength dispersive X-ray fluorescence. And it refers to the process by which the X-ray photons are quantified, detected and quantified. So, wavelength dispersive works on the wavelength of the X-ray photon, which is the energy in the wavelength are inversely proportional. So, the higher the energy, the shorter the wavelength. Energy dispersive works on the energy of the photon. So, in a wavelength dispersive system, the detecting element is actually a scattering crystal whose lattice planes are designed to have a certain spacing. And when X-ray photon, a packet of a wavelet of energy passes through that crystal, it will diffract through the planes of the lattice and based on the wavelength that will exit that at a certain angle. And if you put a detector at that angle, a photon counter, then you will capture that event. And that angle is representative. The angle that the photon escapes the crystal is representative of the energy. So, a wavelength disperses acts on that physical aspect of the wavelength of the photon. And it can measure multi-elements, but you need a detector at every angle that's representative of the elements that you're trying to measure, which is relative to their energy.

Now, in Thermo Fisher, we have some very excellent benchtop and laboratory XRF analyzers utilizing both energy dispersive and wavelength dispersive and have been doing so for decades. We have deep, deep experience in applying both these technologies. We have very excellent versions of both. To do multi-elements with wavelength dispersive, you need something called a goniometer, which would be the detector that I mentioned that sweeps across these different angles and builds your wavelength versus events histogram of the sample.

Now, that is a very excellent method, and it's been used since the earliest days of X-ray fluorescence. In fact, the very first X-ray detectors were based on these scattering crystals. But they are delicate. They have to be temperature stabilized, mechanically stabilized, which you can do in a lab instrument, but it becomes very difficult to do in an online process control environment where you don't have control over all those parameters very easily.

So now you can think, well, if I have to move this goniometer across the crystal to get the different scattering angles, I need to stop each position and make count. So that takes time. So how do you deal with that? Well, you use a very powerful x-ray source. maybe one kilowatt, two kilowatts. So you have a lot of counts. You don't have to measure very long to collect your x-ray photons and get good counting statistics. Now, this scattering process is also relatively inefficient so you need a lot of power. But that's how you get around it.

Now, we also have a version of the instrument where you don't have the moving goniometer. You have fixed angle. what are called monochronometers, where you just have a scattering crystal and detector arranged, let's say, to do copper or moly or iron. And that would be a single channel. It would be very effective. And this is what we see in online WDXRF. They're more compact. They're simpler. They don't have moving parts. So it's a more practical solution to doing WDX online.

Now when I when I talk about EDXRF to end users and they ask this question what's the difference between EDXRF and WDXRF they think about it is that EDXRF is one detector many elements WDXRF is one detector per element. So physically in an instrument cabinet, let’s say you want to measure 15 elements with WDX and you're not going to use a goniometer to do multi-elements. You've got to fit 15 different monochronometers around your zone where you can measure XRF. So it's not very compacted and you get space limited and typically you're limited to about five elements a scattering channel to measure density.

Now, the way EDXRF works, which I alluded to in my previous discussion on the MEP-400, is you have a solid state detector, basically a photodiode that's designed to be sensitive to X-ray fluorescence wavelengths. The energy of that photon is captured into this diode detector, the photodiode and it's converted to an electron charge, the number of electrons is proportional to the energy of the X-ray photon. Then that is converted, that electron charge is moved out of the solid state detector and converted to a voltage pulse. Now, these events happen in fractions of microseconds. They're very short-lived. So the faster you can process these events, the more you can count per unit time.

Now, the modern state of the art EDXRF detector is called a silicon drift detector. And we can have a very large format detector, 50 square millimeters with hundreds and hundreds of pixels to detect x-rays. And that allows us to have very, very high count rates and a big solid angle on looking at the fluorescence coming up our sample. That translates into a much larger spot size than you get with WDXRF. So you get a bigger spot size.

Also, EDXRF is much more efficient than WDXRF. You need using WDX versus EDXRF to get the same count intensity. So, for example, if we're running in our MEP-400, let's say, for example, we're using one watt to get the same sort of count intensity with an equivalent WDXRF system, you need 100 watts. So that translates into more power, more cost, bigger cost. A larger X-ray source to achieve the same results.

Now, EDXRF started out when I first got started in this business four decades ago. We were just starting to put in cryogenically cooled solid state crystals as detectors. Pretty good energy resolution, but nowhere near what you can achieve with EDXRF.

Where WDXRF really excels is in energy resolution, the ability to separate the energies of the X-ray photons. So when you get down on the low end of the periodic table, those atomic numbers and the energies, they start getting closer together. And so you need energy resolution to pull the peaks apart. So WDX has long been recognized as a really good method for that.

EDXRF in the early days was quite limited. The first detectors were called proportional counters, then went to solid state cryogenically cooled. And those performed very well for decades, but they required liquid nitrogen cooling. Now, we got rid of that in 2015 with the MEP-300 and went to the silicon drift detector, which is really superior energy resolution and stability compared to these cryogenic detectors, and you get better performance because of that. But the energy resolution is maybe 150, 160 EV versus WDX, which is maybe 10 EV. Now you might ask, well, isn't better energy resolution better for measurement? And the first answer is it depends. And it depends on whether or not you need to do the peak separation.

Now, what we find is for most base metal slurry applications where you stop it anyway because of the physics, you don't really need this WDX level of energy resolution to separate the peaks for the most part. There's a few cases where you do nickel, zinc, copper, cobalt. are known issues. But with these new detectors in advanced signal processing, we're able to separate these peaks out. So energy resolution is not really the big drawback of EDXRF versus WDX that it was 30, 40 years ago. It's really quite a good method.

And as I mentioned in the MEP-400 discussion. So we collect a lot of information very quickly and it's 100 times more efficient. So we can operate at lower X-ray beam power, which means the cost of ownership for your instrument is far less because the X-ray tube lifetime and replacement costs are much better.
That was another question I was actually going to ask. But one other question that I have for you, let's talk about from a practical standpoint. So let's say that I'm running a copper processing plant and I have EDXRF technology for my probe. But then for some reason, an element that didn't previously exist in the ore shows up in the ore.

For EDXRF, you can basically just calibrate the ore, right?
Well, as long as you can see it. Now, all technologies have a limit of detection, which is maybe that could be another topic of Analyze That, is what do detection limits really mean? They can be quite misleading but its basically there's a level

below which we cannot make a useful measurement and so as long as the concentration of the of element is within the energy range and the detection limit of the device you can you can make a calibration and that's very true with with our systems and the MEP-400 now we we've lowered the detection limit quite substantially compared to the MEP-300. And we're able to see minor elements that we couldn't see before. For example, bismuth, arsenic, and so on, where you're talking, you know, below 100 ppm of these minor elements, we can start to measure them and produce a useful calibration.

How do you do it? Well, if it's only set up to measure lead and zinc and iron, and you start seeing an arsenic peak, and you want to measure arsenic or copper, well, you put in something called a region of interest. It's a software configuration. You define a region of interest in your software configuration, and then you start taking calibration samples, and you use the regression tools to develop a model now. If you don't know how to do that, our field service people can teach you. We can certainly help you sort things out from the applications group here that Kevin runs that I work in.

And usually people who have our equipment in the plants know how to do this. They have learned from our field service people in training how to look after the calibration of the analyzer. So adding another channel, another piece of information about your process stream is not very expensive. So, you know, with any technologies, they have their place, right? Some are better than others and some are better than others in terms of vice versa, things like that.

So just to sum this up, what are three things in which you would make a decision on to use EDXRF versus WDXRF? Just the top three that you could think of.
Yeah, I think that it depends on what I want to measure. So if I'm really concerned about going after minor element trace amounts where the energies are close together, then I'm going to look really hard at WDXRF. But in general, I would say as a more versatile, cost-effective, rugged, and reliable, if I'm responsible for looking after an analyzer in the plant and I have to make it work and have to teach my people how to make it work and keep it running, I want something that's simple, rugged and reliable, that's trustworthy. And so I would in that case, I would be thinking about, well, what do I really need to measure? What has the greatest value?

Sure, I'd like to be able to measure precious metals, if this is a copper concentrator I need first and foremost I want to measure copper very well in all my streams and I want to do with a rugged reliable trustworthy system so those would be your trade-offs. I think they both have their place and there certainly are many many installations of WDXRF around the world doing great jobs in slurry. But EDXRF in this, especially now that we're isotope free, it really can provide very equivalent performance.

One of the other things that I haven't mentioned previously is that one of the challenges of measuring slurry is that the sample that we're measuring is diluted by water, to transport the solids. Now when we do measurements in the lab we're doing it on 100 solids, it's a dry sample so it's at full concentration whatever it is when we take that same sample and it's powder we make slurry out of it let's say it's at 30 solids we're getting one third of the constant apparent concentration in slurry that we are at lab. So how do we deal with that? Well, this has been one of the challenges that was seen in the very early days of applying lab XRF instruments onto slurry. And there are methods for compensating for this effect, and that is by measuring the density of the sample. And we typically do it by weight, percent solids by weight. Now, that is done within the X-ray instrument itself by measuring something called scattering, where X-rays come from the X-ray source. They interact with the sample, they come back into the detector. They aren't fluorescence peaks from an element. They're simply X-rays that have been interacting with the sample and have been scattered back. Well, that scattering region is indicative of the percent solids of the sample. So we can make a percent solids measurement with this scattering information.

Now, when I think about WDX, EDXRF for measuring scattering and specifically measuring percent solids, WDXRF has a very small comparative spot size and measures a very, very narrow band of energy. So if you want to measure scatter to measure percent solids, you really want to measure a wide band of energy and you want to have very high count rate because the relationship between percent solids and the scatter intensity is nonlinear, highly nonlinear. And as you get to the lower percent solids, that that curve really flattens out.

It's a negative correlation and it really flattens out. So you need a lot of counts and a lot of.. to better capture what the scattering matrix, you're better off measuring a wide band of energy. That's very easy to do with an EDXRF system where you can simply put a wide ROI in the spectrum.

So we know that we get very good percent solids measurements, which is very important now in operating these slurry plants because water consumption and water balance is so important.

So, yeah, it seems simple. What is your percent solids? But having that accurate measurement built into your XRF instrument means you don't need a density gauge for those streams because we can give you the percent solids. Now, we know that we can do a better job of measuring percent solids by EDXRF than WDXRF. We've talked to users about this. We have data. If you really want to make an accurate measurement, let's say a percent copper, you need to know what your percent solids is because you need to know what the dilution is. The measurement that we give from the on-stream analyzer is the dry basis. It's the percent copper in the dry proportion of the sample. Not that copper is apparent concentration in the slurry at dilution, but in the solids. So you must have a very... The more accurately you can measure percent solids and then accurately model it and correct for it to give your dry basis assay, the better. So it translates to accuracy. And I think that's a little bit underappreciated by people with legacy WDXRF systems is they, you know, they have what they have and it works well, but it has limitations versus EDXRF it cannot accommodate a wider range of variation in percent solids without having to modify the calibration.

That has a direct impact on availability, reliability, trustworthiness of the assays and so on. So these are all a little bit kind of application dependent. Not all plants have issues with wide range of solids. Some do. Not all plants have really low solids, although we're really seeing this more and more in the cleaner circuit now where we're seeing percent solids down at 10%. So that's a factor of 10 from 100. That is a very significant dilution. And you need a really good system to get a good answer on 10% solids.

Well, I think it just goes to be said that, you know, when you have a technology, you can put it in the right application, you can put it in the wrong application. Some can work in both. Some can work in one or the other. And that's kind of the fun things about different technologies.

Tom, I really appreciate it today. I think I've learned a lot about EDXRF and WDXRF and when to use one and when to use the other. So I really appreciate your time today. And I hope to have you back on another episode of Analyze That.
Yeah, happy to talk about online elemental analysis and particle size as well in mineral beneficiation plants.