Webinar Transcript

An Introduction to Optical Measuring Systems

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After working as a medical technologist for six years in a major university medical center, Alan has spent the last 28 years selling various microscopy instruments, digital camera systems, software, and associated accessories; and supporting and training customers. Since joining McCrone Microscopes & Accessories, Alan has added SEM sales and applications.

Introduction

Hello, thank you for joining us for this webinar "An Introduction to Optical Measuring Systems." My name is Alan Vitous, and I am a technical sales representative for McCrone Microscopes & Accessories here in Westmont, Illinois.

There are a wide variety of attendees here representing companies; I'm sure there's a wide variety of expertise as far as optical measuring. If you are an experienced engineer and are familiar with measuring systems perhaps this might be a useful overview of you. If you are new to measuring, or perhaps find yourself in a position to have to look at a measuring system, perhaps we can provide you with information that will make your job easier.

So, before we go into the measuring webinar, I'd like to talk a little bit about The McCrone Group. It consists of three divisions; the first is our materials analysis division, McCrone Associates. This is an A2LA accredited laboratory, and they provide analysis using applications in light microscopy, electron microscopy, x-ray diffraction, Ramen, IR, metallurgy, and many, many other techniques. So if your company has some samples, some specimens, some material that you need assistance with an analysis, McCrone Associates can help you with that.

Our next group is the Hooke College of Applied Sciences, This is our education and training division. Hooke College offers courses in polarized light microscopy, gunshot residue, specimen isolation, preparation; IR microscopy, and many, many other techniques. A course catalog can be seen on our website: www.mccrone.com/hookecollege.

Hooke College also partners with North Central College in Naperville and Concordia University in providing a 3+1 program that results in a bachelor's degree in applied microscopy or chemical microscopy.

Our third division is McCrone Microscopes & Accessories. This is our instrument sales division. We are a preferred dealer for Nikon industrial microscopes and metrology systems, the national dealer for the JEOL NeoScope benchtop SEM system, and are preferred national dealers for Linkam thermal stage systems, exclusive providers for the McCrone Micronizing Mill and many, many other laboratory tools and supplies.

For more information on any of these three divisions of the McCrone Group, or information as far as how more we can help you, please visit our website www.mccrone.com for more information.

Optical Measuring

Now let's get into measuring.

If someone presents you with a part and says "I need to have more information about this part," you have to make a decision as to whether or not you are performing an inspection application or a measurement

Nikon MM-400/800 series.

application. Inspection applications are qualitative; they're subjective: "Does this part look correct? Is the surface finish correct? Is the color correct? Do I see any damage or wear? Are the parts fitting together correctly? Do I see any defects?" These are inspection techniques and they are qualitative and subjective when you're looking at the part.

On the other hand you may have to do some measuring: "How long is this feature? How large is the hole; is the hole in the right position? How tall is the feature? What is the angle on this feature? Does it meet the specifications?" These are measurement applications. They are quantitative, and they are measurable.

Inspection Microscopes

This is an example of what inspection microscopes look like. The first two here on the left are inverted materials microscopes. The objectives sit here under the stage, you place your specimen here on top of the stage and view them through the eyepieces. You can use a variety of different optical techniques: brightfield, darkfield, Nomarski; and on many of these you can also mount a camera system.

This instrument here is considered an upright materials microscope, looking a little bit more familiar to microscopes that you're used to eyepieces are up here; stages onto which you put your specimen; but the objectives are at the top of the instrument and they look down on your part. You can have two different types of illumination either reflected light illumination or transmitted light illumination through the part. So if you have a translucent part, a clear part, this would be the type of instrument that you'd be looking at.

This is what's called a stereomicroscope. It is a rather lower power microscope. It has stereoscopic viewing to give you that 3-D inspection aspect. This particular microscope as it's configured here on this sheet does not have a place that you can mount a camera but many of them do. So all four of these instruments are considered inspection microscopes. They are tools to allow you to determine surface details, features of the part, but are not measuring instruments.

Measuring Instruments

Two types of measuring instruments that we're going to concentrate on are our profile projectors and toolmakers microscopes, or measuring microscopes.

Comparators

These are examples of profile projectors, or otherwise known as comparators—some people call them shadowgraphs. You can get up to 500X magnification. They may have one, two, or three objectives. They usually have a measuring stick and they will have a screen onto which the image of the specimen of the part is displayed, as you see here on this instrument. You can have two different types of illumination: transmitted light illumination that comes from beneath the specimen, or reflected light illumination—it comes down and shoots light on the surface of the specimen. When light comes up from beneath the specimen it provides a profile of the part that you're looking at, and this is where you would make your measurements.

There are two different configurations of profile projectors. The two on the left are configured as vertical comparators. Again, you put your specimen here on this stage, you have three objectives here that look down onto the specimen, and the image is depicted here on the screen. On a horizontal comparator, the objectives are here at the back and look horizontally across the specimen, and like the others, the images projected appear on the screen.

Many American manufacturers have preferred horizontal comparators because they are much better at handling large, bulky parts, very heavy parts; and because of the heavy industry in the United States, the horizontal comparator has been a preferred instrument for measuring.

Measuring microscopes work in a very similar fashion. They have a measuring stage, they have an area where you have either one objective, or two objectives, or more. You can mount a camera on the top of the microscope, but instead of a screen, you have eyepieces; either a single eyepiece, as in this instrument, or dual eyepieces, as in this instrument. You can get up to 1000X magnification. You may have a turret with multiple objectives and, of course, you can mount a camera on these, as well.

How do you choose? How do you make a decision as to whether or not you need to look at a measuring microscope or a comparator? Well, some of the questions you might ask are: How large is my part? Physically, how large is the part? Or, how heavy is my part? You may have a large part, but you're only interested in a very small area so we have to determine—How large is my area of interest? What is the smallest feature I need to resolve on this instrument on this part? Am I doing simple measurements, or am I doing complex measurements? Is it a simple point-to-point, or will there be multiple measurements involved? Am I doing z-axis? Is there a height that I need to measure? Am I going to use eyepieces, or would a screen be more ergonomically efficient for me? If you are using a screen, perhaps you might want to use overlays, which are specific to parts. Do I want to document this part with a camera? What is my throughput? If you're using a comparator with an overlay, that will allow very fast throughput. If you have multiple measurements to do, that slows down your throughput.

So all of these questions get into making a decision on what kind of instrument you need, what size, and what configuration.

There are two different ways that you can do measurements on a comparator or on a toolmakers microscope. You can either do field of view measurements, or you can measure off of the measuring stage. On a comparator, where the image is projected up onto the screen, you can use overlay charts—you can use measuring charts, and many of them also have a protractor screen for measuring angles. On a microscope, you can do field of view measurements using eyepiece reticles, you can use specialty eyepieces such as a filar measuring eyepiece, protractor eyepiece for measuring angles, and of course you can mount a camera or software. But on a stage measuring system, you can measure larger parts—parts that are larger than the field of view. You can construct features, or relate features that you've measured to each other you can perform z-axis height measurements, and you can relate the features that you measure to a datum.

These are two examples of measuring chart for comparators. The one on the left is a typical toolroom chart. It has a graph on the bottom side that you can use for point-to-point measurements; distance measurements. On the top half of the graph you have various radiating lines out from the center to show you angles, and you have curved lines that will show you radius diameters, if those are important to you. The chart on the right is a specialty chart that you can obtain that shows screw thread pitch dimensions, so if you are measuring thread pitch, you might want a chart like this. You can have custom-made overlays for your comparator that have the profile of your part. In this particular instance, the green line here shows where the proper part would sit, and the dotted lines show the minimum and the maximum tolerances. These charts are custom-made usually from CAD drawings, and they're calibrated to the screen size in the magnification. You can see how this would be very handy and very quick to put a part on, line it up with this outline, and tell whether or not the part is good. As a go/no-go type of inspection, it's very easy to use for inexperienced inspectors, and gives you much faster throughput.

The third way that you can do field of view measurements on comparator is by using a protractor screen. In this sort of instrument you have a screen with the crosshair, all comparators do, and you can line one line of that crosshair up to one side of your angle, rotate the cross hairs around to the other leg of the angle, and read off the angle right here on your screen. This can be switchable with either absolute or incremental, you can also switch either degree minute or degree decimal readouts.

One thing you do have to remember is that your measuring does have to be in the field of view, and you want to have the vertex at the center of the screen. On measuring microscopes, or on microscopes of any sort, you can put in eyepiece reticles for field of view measurements. These are very good for simple length measurements. They can be configured in metric or inch specifications, you can have grid patterns, you can have scales patterns, you can have scales on cross lines, or you could have specialty reticles to put into your eyepieces. This one here on the left is a specialty Walton-Beckett reticles for asbestos analysis, this one here in the middle is a grain-size reticle, for metallurgy.

You can also obtain specialty eyepieces for your microscope. The top one is called a filar micrometer eyepiece. As you look in the eyepiece a scale is broadcast over the field of view, and by turning the knob here on the left, you can make a determination of a very precise point-to-point measurement within your field of view. These bottom three eyepieces are protractor eyepieces. The one here on the left actually has a digital readout, so by putting one leg of the crosshair that you would see in the eyepiece (very much the same way that you would do it on the protractor screen on the comparator) you set a leg on one angle—one leg of the angle; rotate it around to the other leg and then you can read off the degree of rotation. These other two eyepieces have manual reading, but you can still do very, very precise readouts of angle measurements.

Of course there's always software; there are cameras and software packages that you can mount on your microscopes. Nikon Elements is a very comprehensive software package that allows you to do point-to-point measurements, circle measurements, z-axis measurements if you have a z-axis scale; but again, you have to keep the part that you are measuring, or the feature that you are measuring, within the field of view.

I'd like to talk a little bit about field of view, and how the comparator's screen size affects the field of view that you have, and how it compares to measuring microscopes. Let's take a 10X magnification, for example. The magnification of the objective is the total magnification of the system. With a 10X magnification on a 12-inch V12 comparator, you will see that the field of view is about 30 mm. If we go up to a 20-inch screen, the 10X will give you 50 mm because of the larger screen size. If you look at a measuring microscope, in order to get to 10X, you would have to multiply the 1X objective times 10X eyepieces. This combination gives you a 22 mm field of view similar to that of a twelve-inch comparator, but much smaller than the 20.

If we go up to a 100X objective, again on the 12-inch comparator you have a 3 mm field of view, very similar to a toolmaker's microscope at 2.2 mm, but again not nearly as large as on a 20-inch comparator with a 5 mm screen. So you can see that if you need to measure within the field of view but you have a larger feature that you need to measure, you need a larger screen on your comparator.

In general, comparators usually provide lower magnification in higher field of view. Microscopes usually provide higher magnification and better resolution.

Stage Measuring Systems

Now, let's talk about stage measuring systems. On these instruments—both comparators and microscopes—you can measure with the X-Y stage. The X-Y table has linear or rotary encoders that allow you to determine the distance that the table travels, and as I said before, you can construct features, or relate features to other features, that you've measured. For the purpose of this webinar, I'm going to only touch on two types of digital readouts. The first series—the Nikon SC series—can be had as either an X-Y digital readout or an X-Y-Z three-axis digital readout. The more complicated—or I should say more capable readout system—is the Quadra-Check system that you see down here.

Quadra-Checks [used to be] you're probably familiar with them. They're marketed by a company called Metronics. Now they have the Heidenhain name on them; Heidenhain is the parent company of Metronics. The movement on the stage is detected and measured by the encoders on the stage, and remember, in order to do a z-axis measurement, you need an encoder on the z-axis of your measuring microscope. This is a very basic overview of the front panel of the Quadra-Check. As you can see, you have keys set in different groups, to set the mode or the features that you're going to be measuring. When you talk about the mode, you can either set it to measure in millimeters or inches, and you can toggle back and forth; this also allows you to set a datum, and a datum is merely a zero point on your part usually called out on the blueprint that allows you to determine where on that part the feature is that you are measuring. You can set the datum, and then by looking at either the X-Y dimensions or you can look at the radius and the angle; the radius and angle dimensions, you can tell where your features are that you are measuring, and of course there is a help key.

In order to measure a part, you want to start by establishing the part position on the stage. You'll skew the part, you'll establish the zero point, or the datum, and you'll measure the feature. In order to skew the part, you will measure or probe. On this part, for instance, this bottom line—this will allow you to set x-axis of the part to the x-axis of the stage. To establish a datum, you now will probe this side of the part—the y-axis—and construct a point. That point is going to be your datum. You zero the counters at that point, and now every position that you measure on this part every position that you measure on this will be referenced off of this datum point. You can then look at your blueprint to see if those features are in the right place, and if the dimensions make sense. You can measure many different features; probe them; you can probe a point, you can do many points together to form a line, you can determine—is it a circle? You can go point-to-point distances, you can measure angles, and of course you can skew your part.

There is also a feature called Measure Magic® which is interesting. You can probe a group of points, and depending on the distribution and the location of these, Measure Magic will determine whether or not you are measuring a circle, or an angle, or a line. Of course, the operator can change the feature if Measure Magic gets it wrong.

Features that are typically probed are points, or lines, or circles, or point-to-point measurements. Features that are constructed are features like angles, where you have two different lines and you want to find the angle between them, or distances: between points, between lines, between a line and a circle; things of that nature.

You can set in the system whether or not you want to stick with, for instance, a three point circle, or if you want to boost it up to five points; if you want to determine a line with two points, or three points, or four points. In general, more points result in higher accuracy of the points of the feature that you are probing. You can also set forward or backward annotation. Forward annotation sets the number of points whereas backward annotation allows you to probe more points than the minimum number of points required. Some points can be probed. This is an example of probing points on this part to determine an angle. So you would probe along one leg—in other words, you would move the part that's under the crosshair—set the cross hair on that edge, hit enter. Come down to another point on that line, and hit enter. Then you'll probe these two points: one point on this line here, and another point on this line here, hit enter. When you hit "finished," that will give you the angle between these two lines. Or, you can construct an angle. Here, we've taken line number four that we've already probed, and line number five, and asked it to determine the angle between the two. You can also determine whether or not you want to look at the included angle, or the angle +180, the angle -180, etc.

You can look at individual features. Here, for instance, we've probed a circle, and it looks like they've chosen eight points to determine a circle. You can, at this point, determine whether or not you want to use a least-squares best fit algorithm to determine your circle, or an ISO schema, or if you want to look at the outermost three points to determine the circle, or the innermost three points to determine the circle. You have those options.

You can also construct distances. In here, we've measured two circles; circle number four and circle number five, and now we want to find the distance between those two circles. Do we want to find the distance between center point to center point? Or do we want to find the distance between the nearest edges? Or do we want to find the distance between the furthest edges?

You can construct other features, again, out of features that you've measured previously. This one is called a bolt hole circle. Think of a wheel on your car: you have five holes on the wheel for the lug nuts to attach the wheel onto the stems of the hub, and they are centered precisely around a center hole. In this case, we have probed three different circles previously, and now we're calling up these three circles and making those as three points to determine this one larger circle. You can construct, or probe, intersection points. In here, you have two lines: line number one and line number two; and we create point number three right here from the intersection of these two lines. Remember, this is exactly what we did when we set our datum, our zero point, on our part. Often, these zero points or datums, or these points that are constructed, can be off of the part themselves.

Measuring Systems Specs

I'd like to talk a little bit more about the various profile projectors and measuring microscopes that we offer. The first one is the V12. This is a 12-inch screen and has a stage up to 10 x 6, or as small as a 2 x 2 travel. You can have them with or without a built-in digital readout, and they can be configured with or without the digital protractor screen for measuring angles. This is a benchtop instrument that either has to be on a stand, or a benchtop.

This instrument is the horizontal comparator that we referred to earlier. This is the H-14-LED, this has been just newly redesigned with LED illumination, so it's very bright. It has a 14-inch screen, and I want you to notice that this 14-inch comparator can hold up to a hundred and twenty-five pounds—a very heavy part. Large stages on vertical comparators can hold up to about 44 pounds; smaller stages only about 11 pounds.

This one is the V20—a 20-inch profile projector. Again, the screen is 20-inches in diameter. It has a turret with three objectives: 5X, 10X, 20X; 50X, and 100X objectives are available. And this is a floor standing instrument.

There are three different varieties of measuring microscopes. This is the smallest one, the MM-200. It can be configured in three different ways: one with either a monocular eyepiece tube, which we saw originally, or you can have two versions with a camera only and no eyepiece. One with a fixed magnification objective, and one with a zoom objective. The MM-200 comes standard with a 2 x 2 stage: 50 mm x 50 mm travel.

The larger instruments, the MM-400 and the MM-800, can have various configurations. Both systems can be ordered with or without a z-axis encoder, both can be motorized, and both can be configured with either a simple X-Y digital readout, or Quadra-Check. If you look at the configurations, the L systems have the z-axis, the z-axis micrometers, and the M stands for motorized. Some common features from both the MM-400 and MM-800: they have similar stages, but the MM-400 can only go up to a 6 x 4; whereas the MM-800 can go up to a 12 x 8. Because the MM-400 is shorter, is a smaller stage, you have a maximum a-height of 150 mm, whereas the MM-800 gives you an extra 50 mm of height. You can have either monocular or trinocular heads, you can have single, or dual, objective mountings, and you can also have heads that have what's called a focus aid. If you're familiar with the SLR with the split-screen sort of situation, that's what this looks like. It's a split-screen where you focus your instrument until the image is clear, and that gives you accurate focusing.

This is a screen that shows you the various stages; it's very difficult to read, I don't expect you to read them; but again, this shows you the configuration of stages from the 2 x 2 all the way up to the 12 x 8. Depending on size of the specimen, the area of interest on your specimen that you need to measure, and the instrument that it goes on, that will help you determine which stage you need.

There are also many other instruments—measuring instruments—that are more sophisticated. We won't go into them on this webinar. There are computer-based systems where you can plug your comparator or toolmakers microscope into the computer software and do the measurements through the computer, or you can have more advanced systems, like the Nexiv, which is a multi-sensor system; you can have touch probes or video probes; it's all CNC programmable.

You can have a CNC measuring instrument, like the Altera systems. You can do a 3-D laser scan investigation of your part, and we even have x-ray applications.

Conclusion

That was a brief overview of basic measuring systems. If you have specific questions about any of the systems that we talked about, measuring applications, or if you just need additional information, please contact me at 630-734-6473, or drop me an email at avitous@mccrone.com.

Thank you very much for attending.