Episode Book

EPISODE #5737

Why Measuring a $4 Spudger Tip Is Weirdly Hard

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SYNOPSIS

Daniel wrote in with a confession — he loves his spudger, the humble pry tool every electronics tinkerer owns — and a problem: he wants to measure the thickness of its tip, but the tip is sub-millimetre and his caliper can't honestly read that small. What follows is a tour through the surprisingly deep world of precision measurement, from calipers and micrometers to ultrasonic thickness gauges and white light interferometry, plus the materials science behind why you can't make a spudger tip both thinner and stronger at the same time. If you've ever wondered where your tools stop being trustworthy, this one's for you.

TRANSCRIPT



Corn

Daniel wrote in this week with a confession and a problem. The confession is that he loves his spudger. Calls it one of the great unloved tools, the most versatile thing anybody working on electronics owns. It pries, it scrapes, it lifts adhesives, it opens things that were never meant to open. And his problem is that the two properties he actually wants in it, an extremely fine tip and extreme strength, pull in opposite directions, which he knows, and he fell back on his reserve spudger while his favourite was misplaced and started wondering whether he could put a number on the thing instead of flying in the dark.



Herman

A number on what, exactly?



Corn

The thickness of the head. He wants to be able to say "this one is sufficiently thin" and have that be a measurement rather than a feeling. Except the tip is under a millimetre across, which is below the smallest increment his caliper can reliably read. So the ask runs in two parts. What tools exist for precise measurement below the caliper, and how does that connect to metallurgy?



Herman

That is a beautiful question, and I mean that structurally. He's asked about a four-dollar piece of plastic and backed into a real metrology problem.



Corn

Four dollars is generous. Three ninety-nine.



Herman

Which makes it better, honestly. The cheaper the object, the more embarrassing it is that measuring it turns out to be hard.



Corn

So let's start with what a spudger actually is, and why Daniel's right that it's underappreciated.



Herman

It's a prying tool, and the textbook description is exactly what he said. A wide flat head like a screwdriver blade, extended out into a wedge so you can slide it into a narrow slot. That's the business end. The other end is usually a point or a hook, and the reason for that is that you can't get a wedge into a gap that doesn't exist yet. So you dig the point in first, open an initial gap, and then rotate the wedge into it.



Corn

Which is why it feels like a mini crowbar. That's the whole motion. Find the seam, get under it, lever.



Herman

Exactly the crowbar motion, but with the crucial difference that you're prying on something you very much do not want to scratch. The material choice follows from that. A spudger for plastic pressure-fit components is an insulating stick, wood or plastic or nylon-fiberglass, because a metal blade against a plastic housing leaves a mark and a conductive tool near a live board is its own kind of mistake.



Corn

And then there's the case where you're actually prising metal apart, where the tool itself is stainless steel or another metal, because a nylon wedge just folds.



Herman

There's an old one worth knowing about, the orangewood spudger. It shows up in electronics assembly and soldering work because the wood takes heat without charring the way you'd expect, and the grain is dense enough that the tip holds a shape. It's a stick. It's a very specifically chosen stick.



Corn

The canonical example for most people is going to be the iFixit one. Three ninety-nine, sold as the essential ESD-safe pry tool, and it's been reviewed about eleven hundred times at four point nine stars, which for a three-dollar piece of nylon is a lot of people bothering to say something nice.



Herman

It's their version of Apple's Black Stick. Apple part nine two two dash five zero six five, the tool Apple-certified technicians use. Same shape, same idea, and you can buy it for the price of a coffee instead of needing to be in the programme.



Corn

And on the ESD side, those conductive spudgers are typically a conductive plastic loaded with about fifteen percent glass-filled nylon, which is what lets you take one near an ESD-sensitive component without being the reason the component stops working.



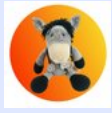
Herman

Jonard makes one, the AT three one one two, that's a plastic pencil with a point on one end and a screwdriver tip on the other. Forming, guiding, separating fine wire terminals. It's a useful little thing and it costs less than lunch.



Corn

So the tool is cheap, it's everywhere, and nobody thinks about it. And yet it sits at the exact boundary where ordinary measurement tools stop being trustworthy. That's where Daniel's question bites.



Herman

The tip is sub-millimetre. His caliper's smallest reliable increment is a millimetre. So he's asking for resolution an order of magnitude below what his instrument can honestly give him, and he's asking it about an object whose whole selling point is that it's thin and soft enough not to damage what it touches.



Corn

Which is a lovely trap, because the property that makes it a good spudger is the property that makes it hard to measure.



Herman

So the thin-strong trade-off first. It's real and the market is the proof. iFixit wanted a stronger spudger and the way they got it was a material change, not a geometry change. The Carbon Fiber Spudger is made from something they call Fixite, which is a custom blend of carbon and glass fibers in nylon. Their claim is that it's twice as strong as the standard spudger, and the specific test is that in a bend it needed twice as much force to reach a two centimetre deflection.



Corn

Twice the force, same deflection. So it's stiffer under load, which is the thing you actually feel when a clip is stubborn.



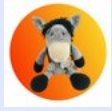
Herman

And it holds its edge. Fixite keeps its sharp edges against scraping and poking over time where the plain nylon rounds off. iFixit's line is that it won't jump as much when you finally get a ribbon cable up or a clip popped out, and that you can exert greater force on delicate parts with less effort.



Corn

And the caveat is the interesting part.



Herman

The caveat is that iFixit says outright it is not heat-resistant enough to use for manipulating melted solder, and if that's what you're doing, go back to the standard glass-filled nylon spudger. They sold you a stronger tool and then told you not to use it for the thing the old tool was good at.



Corn

Because the strength came from a material that gives up something else. You can't have all of it.



Herman

You can't make the tip thinner and stronger at the same time in the same material. Not at a fixed thickness. So the answer is to change the material, and then you inherit that material's weaknesses. That's the materials science answer to what looks like a geometry problem, and it's exactly the shape of the question Daniel's poking at.



Corn

Now the measurement. Where does the caliper actually stop being honest?



Herman

The clean framing is this. If you're holding a feature to plus or minus a tenth of a millimetre or looser, a digital or vernier caliper is fine. It's the right tool. Between plus or minus two hundredths and plus or minus a tenth, the caliper is at the edge of what it can do, and an experienced operator will confirm anything borderline with a micrometer. And tighter than two hundredths of a millimetre, you need better instruments. Full stop.



Corn

So a tenth of a millimetre is the caliper's honest working floor.



Herman

And the spudger tip is under one millimetre, and the part of it Daniel cares about, the thickness at the very edge, is well below that. He's in the band where the caliper is already guessing.



Corn

The micrometer is the classic next step down. What is it, mechanically?



Herman

It's a G-clamp with jaws. That's the honest description. You've got a very accurately calibrated screw thread, most commonly a twenty-five millimetre frame, and you turn the thimble until the jaws close on the thing. The screw thread is the whole trick, because a screw converts a big rotation into a tiny linear advance, and if you cut the thread accurately you can read that advance off a scale. Typical precision is a hundredth of a millimetre, or a thousandth of an inch, and a vernier-equipped micrometer adds another fraction of a digit on top of that.



Corn

And there's a hands-on test that lands right on Daniel's question. Somebody at Hackaday measured a human hair.



Herman

With three different micrometers. A cheap eight-pound Daniu read zero point zero two millimetres. A Mitutoyo one oh three dash one three seven read zero point zero six five. A vintage Moore and Wright number nine six four read two and a half thousandths of an inch, which is zero point zero six three five millimetres.



Corn

The two good instruments agree. Sixty-five microns, sixty-three and a half microns.



Herman

And the cheap one says twenty. It's off by a factor of three, on a hair. And the reason is that it wasn't measuring the hair, it was measuring its own play. The thread had slop in it and the jaws weren't flat, and you could see light coming through between them when they were closed.



Corn

Light between closed jaws.



Herman

On an instrument whose whole job is to tell you the gap is zero. It resolves to a hundredth of a millimetre and the answer it gives you is fiction.



Corn

There's a second test in there that's arguably better for this episode. The PCB.



Herman

Two-sided copper board. Cheap digital caliper read one point six. Plastic caliper read one point five five. Mitutoyo read one point six zero. So the good caliper agrees with the nominal thickness, and the cheap digital caliper's problem is that it resolves the copper layers themselves, all hundred microns of them, as one ambiguous lump. Hundred microns is its resolution limit, and the copper layers on a board are right at it.



Corn

So it can't tell you where the board ends and the copper starts.



Herman

Can't tell you the difference between the laminate and the layer on top of it. Which is a hundred-micron question, and the tool's whole problem is hundred-micron questions.



Corn

And then there's the line from a machinist about calipers that I think is the best thing in all of this.



Herman

A carbide grinder, someone who works to tolerances far below anything a caliper can touch, calls a vernier caliper the guessing stick. Because its precision is several factors of ten above her working zone. From where she stands, a caliper isn't a measuring instrument, it's a rough guess you write down.



Corn

Which reframes Daniel's whole problem. It's not that his caliper is bad. It's that every instrument is a guessing stick to somebody. Precision is relative to the work, and the spudger sits right at the boundary where the caliper stops being the right tool and starts being the wrong one.



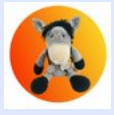
Herman

And here's the thing worth sitting with. The micrometer is the next step down, and it's a step down, and a good one agrees with another good one on the width of a hair. So if Daniel just buys a micrometer, he's done, right? He measures his spudger tip and gets a number.



Corn

I'm guessing no.



Herman

No. And this is where it gets interesting, because the next tier of instruments exists, and the reason you'd need it isn't resolution. It's contact.



Corn

So below the micrometer, what's actually available?



Herman

The next practical tier for thin material is ultrasonic thickness gauges. These work by sending a pulse of sound into the material and timing the echo off the far surface. You need to know the speed of sound in the material, and then the time gives you the thickness. YUSHI's PM4 Gen three claims a resolution of zero point zero zero one millimetres, a thousandth of a millimetre, and ultra-thin measurement down to zero point one three millimetres. Their DC two thousand C covers zero point six five to four hundred millimetres. There's a TI dash zero zero seven X that's built specifically for thin-wall metal and plastics, covering six thousandths of an inch up to an inch.



Corn

And none of that touches the object. It's sound. You couple it with a bit of gel and it reads through the material.



Herman

It's non-contact in the sense that matters, which is that it doesn't clamp the tip. And you can go further. White light interferometry, coherence scanning interferometry, is the modern standard for three-dimensional non-contact measurement of surface topography. Bruker describes it that way. Micro-Epsilon's interferoMETER 5200 dash TH measures transparent layers as thin as one micron, with sub-nanometre resolution, at up to twenty-four kilohertz. That's a measuring rate fast enough to watch a surface move.



Corn

One micron is a thousandth of a millimetre. Sub-nanometre resolution on top of that.



Herman

And it's optical, so nothing is touching the part. That's the whole point of that class of instrument. There's also optical profilometry and stylus profilometry, both used for film thickness and step height. A NIST paper describes using a stylus profilometer and an optical interferometer together to measure a suspended MEMS layer, which gives you a sense of where this sits in the world. This is the instrumentation that semiconductor and MEMS people use.



Corn

Then there's the frontier, which is absurd in the best way.



Herman

There's work on coherence scanning interferometry for thin-film thickness where the field of view is millimetres across and the lateral resolution is micrometres, and the dominant error source is the refractive index of the film. A one percent error in the index gives you about a one percent error in the thickness. Which is a wonderful reminder that you can have an instrument good to nanometres and still be wrong by a percent because you got a material property slightly off.



Corn

The instrument is precise and the physics is approximate.



Herman

There's a recent paper on white light interferometry measuring films down to a few nanometres, with an open-source Python library, optifik, if anybody wants to go down that road for fun.



Corn

The answer to Daniel's question is yes. You can measure the thickness of a spudger tip. Ultrasonic gauge, optical profilometer, white light interferometer, all of them will do it. But here's the catch, and it's not about resolution.



Herman

It's about the object fighting the instrument. And this is the part I want to get right, because it's the real answer. A commenter on Hacker News, someone who clearly does precision work, put it flatly. Ten microns is not reliably measurable by a cheap caliper, and even if you try it with a good caliper or a good micrometer, you'll find that everyday objects simply cannot be reliably measured at that level of precision. You need cleaning procedures, standardized handling, standardized sampling. The instrument is only part of the answer.



Corn

Cleaning procedures. You have to clean the object before you measure it, because a fingerprint is thicker than the tolerance you're chasing.



Herman

A fingerprint is tens of microns. You are measuring the fingerprint. You have to handle it in a standardized way, because how you hold it changes it. You have to sample it in a standardized way, because the tip isn't one thickness, it's a wedge that tapers, and where you put the caliper jaws changes the number.



Corn

So "the thickness of the spudger head" isn't even a well-defined quantity. It's a question about a specific point on a taper.



Herman

That's exactly why a single number is so hard to pin down. There's a second commenter who's useful here. A caliper is fine for thousandths of an inch on hardened steel gage pins. A point two one zero pin read point two zero nine five, and that's a real measurement under real conditions. But if four ten-thousandths of an inch are important to your project, you need a micrometer. Which is the same boundary Daniel's sitting on, just on a different object.



Corn

The gage pin is hardened steel. The jaws don't change it. Its geometry is defined. So the caliper works.



Herman

The spudger tip is soft, thin, and flexible, and it deforms under the jaws. Which is the second-order insight I want to land. The measurement problem here is really a handling problem. A micrometer clamps. A clamping jaw on a soft, flexible nylon tip compresses it. You're not measuring the tip, you're measuring the tip under load, which is a different object.



Corn

Every contact instrument has already changed the thing before it reads it.



Herman

Which is precisely why non-contact methods matter for this specific object. It's not that white light interferometry is more precise, though it is. It's that it doesn't lean on the thing. For a metal gage pin, contact is fine. For a spudger tip, contact is a category error.



Corn

The answer to "how do I measure my spudger tip" is that you mostly don't, with the tools you'd buy. You can get close with a good micrometer if you're careful and accept the compression. You can get honest numbers with an ultrasonic gauge or an optical instrument, and those start at four figures and go up. Four figures to measure a three ninety-nine tool.



Herman

That's the ratio that makes the whole thing funny. You'd spend a thousand times the cost of the object to characterize it properly. And people do exactly that, just not usually for spudgers.



Corn

Now the metallurgy end, because Daniel explicitly asked how this connects.



Herman

The framing is well-motivated even if I want to be honest about the edges of what I know. iFixit solved the strength problem with a material change, carbon and glass fiber in nylon, and inherited a temperature limitation as the price. That's the trade-off in miniature. In metals, the reason you can't have a tip that's simultaneously thinner and stronger at the same material is that the properties that give you strength and hardness and the properties that give you toughness pull against each other. A harder steel resists deformation, and it also cracks instead of bending when you push it past its limit. So you make the tip thinner and it gets stronger in one sense and more brittle in another.



Corn

You tune the material to the failure you'd rather have.



Herman

That's the whole discipline. You pick what breaks and how. For a thin pry tip you want it to bend a little before it snaps, because a snapped tip is a hazard and a bent tip is an inconvenience. And I should flag that I don't have a specific source in front of me for carbide versus tool steel versus spring steel in thin pry tips, so I'd rather say the shape of the trade-off than name numbers I can't back up. The direction is solid. The specific alloy recommendation I'd want to check.



Corn

The direction is what Daniel was after anyway. Thin and strong are in tension because thin and strong are in tension in the material itself, not just in how the tool feels in your hand.



Herman

The way you resolve the tension is the way the metrology world resolves everything. You measure, you characterize, you pick the material that behaves best at the thickness you need. Which brings the whole thing around. To know whether your tip is sufficiently thin and strong, you have to be able to measure it. To measure it, you need instruments that don't deform it. To not deform it, you need non-contact methods. And the whole loop is bounded by what your instrument can honestly tell you.



Hilbert

I used to have one that was thinner than anything you can buy now.



Corn

How much thinner?



Hilbert

No idea. That's the whole problem. It was a flat blade about the width of a thumbnail, and it had been ground down on one side, by me, on a bench grinder, badly, and the tip of it would go under things that nothing else would go under. I lost it in a move. I have been trying to replace it for years. I've bought the iFixit ones. I've bought the carbon fiber one, which was sixty dollars with shipping, and it is very good, and it is not that tool. I've bought the cheap ones off the internet, a bag of ten for eleven dollars.



Corn

None of them are the same.



Hilbert

None of them are the same. And I measured all of them with a cheap caliper, and they all read the same. Hundredth of a millimetre, all of them. Which I know is useless, because the caliper can't tell the difference. So I have ten spudgers that measure identically and one of them is right.



Corn

Was the old one actually thinner, do you think? Or does it just feel thinner?



Hilbert

That's what I wanted to know. I took it, before I lost it, to a friend who worked in a machine shop. He had a micrometer, a proper one, a Starrett. And we put the tip in it and he read the number and then he laughed, and he said the micrometer was compressing it. That you can't measure something that thin and that soft with jaws that clamp. The jaws close, the nylon squashes, and the number you get is the number the jaws decided on.



Herman

You never actually got the measurement.



Hilbert

I got a number. I don't believe the number.



Corn

That's the whole episode in one anecdote, and he got there with a borrowed micrometer and a friend who laughed at him.



Herman

The object fights back. He said it in four seconds and it took me twenty minutes to get there through the datasheets.



Hilbert

I still have the receipt for the carbon fiber one. Sixty-one dollars and change. I keep it with the other paperwork.



Corn

What does "sufficiently thin" even mean for a tool that costs three ninety-nine, when the instrument that could tell you honestly costs more than a used car and a micrometer might squash the tip before it reads it?



Herman

It means the number is available, but it's not consumer-grade. The tools exist. Ultrasonic, optical, interferometric. They're real and they work. They're just not what you buy to characterize a four-dollar pry tool.



Corn

Which puts the spudger exactly at the boundary where ordinary measurement stops being trustworthy. And that boundary turns out to be a materials problem as much as a metrology one, because the reason the tool is hard to measure is the same reason it's good at its job.



Herman

The object that's thin and soft and doesn't mar what it touches is the object that deforms under the instrument that would measure it. You can't separate the measurement from the thing you're measuring.



Corn

Hilbert's friend laughed at him for a reason. The instrument was right and the answer was wrong.



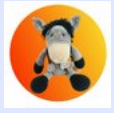
Herman

There's something in that worth keeping. You can love a tool without being able to prove why it's better. Hilbert's been chasing that spudger for years on nothing but feel, and the instruments that could settle it are all beyond what you'd spend on the question. That's a deeply human relationship with technology. The unloved tools are often the ones we care about most, and the reason we can't say why is that measuring why turns out to be hard.



Corn

Which is probably why Daniel loves his. You know it when it's right.



Herman

You can't put a number on it.



Corn

That's the show. Thanks to Hilbert Flumingtop, our producer. This has been My Weird Prompts. If you enjoyed this one, leave us a review, it helps other people find the show. We'll be back soon.