A theory of how the WE diamond pastes work

Posted by mark76 - 01 Apr 2012 15:06

When I first saw Tom's microscope photographs of the edge of a knife after stropping with the 14 micron and 10 micron diamond pastes I was baffled. I was it again when I was able to repeat this myself. Even though the edge got very smooth and sharp, there were only tiny scratches caused by the pastes. How could pastes that were so little abrasive create such smooth edges, both on balsa and on leather?

I did some additional experiments and a bit of thinking. I think I now know why it was so difficult for me to comprehend how the diamond pastes work: I was trying to explain what I saw through the microscope in terms of assumptions I held about why stropping with the diamond compounds worked:

- Leather has a stiction that causes it to burnish the edge, i.e. smear out metal over a larger area that causes scratches to become less wide and less deep or sometimes even to disappear.
- The diamond pastes are abrasive because they remove metal by making lots of scratches with a width and a depth of their specified micron size (or a little lower, since only a part of every diamond particle would touch the edge).
- The diamond pastes work on leather due to the dual effects of burnishing and abrasion.
- The diamond pastes work on balsa due to abrasion.

Tom had already shown that the second assumption was likely not true. It dawned on me when I saw with my own eyes that the first assumption was not true either. The additional experiments and thinking showed that all four assumptions are wrong!

Yet these pastes do work. So I tried to come up with an alternative explanation. You can read it in full on my blog
. But in short I think the following is happening:

- Both the balsa and the leather strops are hardly abrasive by themselves. They do not cause much burnishing by themselves either.
- The strops become effective when loaded with the diamond pastes.
- The diamond pastes cause a lot of burnishing, but hardly any abrasion.

It is the pastes that do the work, not the strops. And these pastes are hardly abrasive, but have a strong burnishing power.

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Re: A theory of how the WE diamond pastes work
Posted by cbwx34 - 31 Oct 2012 13:22

I never thought I'd see "fuchsia" in a sharpening forum....

Maybe someone who's a member of an engineering forum could post these pics and solicit some responses there?

I also had another thought along with trying plain leather would be to try balsa plain and/or loaded... see what that shows.

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Re: A theory of how the WE diamond pastes work
Posted by Billabong - 31 Oct 2012 13:36

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cbwx34 wrote:

I never thought I'd see "fuchsia" in a sharpening forum....

Me either, but it seems to work well.

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Re: A theory of how the WE diamond pastes work
Posted by wickededge - 31 Oct 2012 15:00

Okay, more photos raising more questions. First the 50# sample followed by the strops with no abrasives:

now plain cow leather, moistened with alcohol:

and then plain kangaroo leather, moistened with alcohol:

Next I'll post some pictures after using strops with some abrasives.

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Re: A theory of how the WE diamond pastes work

Posted by wickededge - 31 Oct 2012 15:03

First off is .125 CBN on Nano-Cloth:

now 3.5um Diamond on Balsa, moistened with alcohol - 5 strokes:

and then 3.5um Diamond on Leather, moistened with alcohol - 5 strokes:

Clearly there is plenty of abrasion going on with the 3.5um diamonds.

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Re: A theory of how the WE diamond pastes work

Posted by wickededge - 31 Oct 2012 15:07

There was absolutely no 'stiction' going on with the plain leather. It was just gliding smoothly over the metal. I think I'm somewhat stuck here until the plain paste arrives and I can do some true apples to apples comparisons. I'm thinking of .5um diamond paste on leather vs. .5um diamond on balsa vs. plain

paste on leather vs. plain paste on balsa. .5um is visible in the scope but shouldn't be so abrasive as to immediately obliterate the sample like the 3.5um does.

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Re: A theory of how the WE diamond pastes work

Posted by wickededge - 31 Oct 2012 15:13

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For grins, I completed 60 strokes with the 3.5um Diamond on Cow Leather:

The one thing I have learned is how to get back to the same spot on the sample in the microscope's field of view

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Re: A theory of how the WE diamond pastes work

Posted by wickededge - 31 Oct 2012 15:20

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Here's a close up:

The big gouge measures 38um x 12.5um.

If we keep this up, we're going to have to start naming features like astronomers do on the moon and planets.

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Re: A theory of how the WE diamond pastes work

Posted by PhilipPasteur - 31 Oct 2012 19:56

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Hey Clay,

Interesting ..I was going to try to circle those aqua areas myself.

That small feature looks like it may have been a thin flap in the 50 grit photo, cut by the diamonds. Being as this as it is, it looks like it got sort of folded over and moved a bit and flattened. This might not take much force. After all the piece is probably not as thick as a piece of aluminum foil.

One thing to remember as well. There is a grit distribution in any compound. There are probably abrasive particles in the 0.75 micron compound that range from at least 0.25 to maybe 1.5 microns. These varying sized grits could also be contributing to the smoothing at a level finer than what we can resolve even at this magnification.

Some of the other features definitely look like perhaps they may have been changed by abrasion, albeit very fine abrasion.

The fushia area on the second photo looks like metal has been removed... and smoothed. Perhaps again, abrasion.

I found it very interesting that the blank leather strops had virtually no effect at all. The Kangaroo seemed to make more of a change. This runs a bit counter to what we have seen where "roo strops seem to not contribute to the process much at all when used with abrasives. ???

This is very interesting. I wish I had more experience at interpreting features and their causes at this level of magnification.

Phil

wickededge wrote:

I circled some spots on the images so we'd have some things to compare. Here is the blade after the 50# diamond plates:

and here it is after 5 strokes with the .75um strops:

In the green circle and to some extent in the fuchsia ellipses, you can clearly see signs of abrasion from the .75um CBN. In the red and aqua circles, it looks like the metal has been dragged around a little bit. It has an almost liquid appearance *as though* it had flowed.

I don't have the background to speak to this, but I wonder, as Phil has voiced, if there is enough local pressure to move these delicate structures and deform them. I measured the little elongated structure in the red circle (after being stropped) to be 1.6um, which is very tiny. How many pounds per square inch would be needed to get something that small to flow? Even more to the point, can the leather grab surface molecules and shift them, like buttering bread? The next round of testing should be interesting. I'll try it with alcohol moistened strops with no abrasive other than the grain of the leather. Once the plain paste comes in, I'll try to duplicate the level of stiction I'm getting and test that way too, maybe on kangaroo.

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Re: A theory of how the WE diamond pastes work

Posted by mark76 - 01 Nov 2012 05:42

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wickededge wrote:

There was absolutely no 'stiction' going on with the plain leather. It was just gliding smoothly over the metal. I think I'm somewhat stuck here until the plain paste arrives and I can do some true apples to apples comparisons. I'm thinking of .5um diamond paste on leather vs. .5um diamond on balsa vs. plain paste on leather vs. plain paste on balsa. .5um is visible in the scope but shouldn't be so abrasive as to immediately obliterate the sample like the 3.5um does.

This is a very interesting result. I already knew that loaded strops (both leather and balsa) can be quite effective, but I also thought that plain leather would have some effect. But apparently leather does very little by itself. This makes me wonder why stropping on plain leather is often seen as effective, particularly when doing straight razors. Is it only a matter of straightening the edge?

I recall a blog by Michiel (on belgiansharpening) where he showed that plain horse leather does have an abrasive effect. If I recall it correctly, he explained that this is due to the silicates embedded in the horse leather. And I think that some of your pictures at 200x also showed that plain leather had some abrasive effect (but maybe this was distortion due to the lower magnification).

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Re: A theory of how the WE diamond pastes work

Posted by AnthonyYan - 01 Nov 2012 05:42

Wow, what a fascinating thread, I've only caught up reading recently.

Clay, those pictures are awesome!

I don't have too much to add to the speculation, but I have some information that might be relevant.

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(1) Abrasion is a very complicated subject. There are entire engineering books about just abrasion, and then separate entire engineering books about polishing and lapping. When abrasion is not desirable, it's called lubrication. And lubrication has entire books written about it. Not to mention, friction is poorly understood, even today, despite centuries of scientific study. My thought is to speculate, make theories, and do tests, but then to keep in mind that such things can be insanely complicated which means we could easily be wrong.

btw, I hope to eventually read two engineering books, one on abrasion, and another on polishing and lapping.

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(2) In Prof. John Verhoeven's technical report, _Experiments in Knife Sharpening_, he has several scanning electron microscope (SEM) images of knive edges before and after stropping. He also tried stropping with and without compound. Verhoven's pictures are the highest resolution and most detailed images of knife edges I have seen so far. It may be worth reviewing his work, and comparing notes with Clay's studies.

www-archive.mse.iastate.edu/fileadmin/ww...even/KnifeShExps.pdf

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(3) Just a reminder of length scales relevant to knife sharpeners:

The two most important length scales are:

0.4 microns, which is the sharpness of a modern razor

0.2 microns, which is the resolution limit of optical microscopes. btw, this resolution limit is from physics of light, which diffracts slightly as it goes through the microscope objective. That slight diffraction causes blurring. Only very high-quality optical microscopes can approach this resolution limit. I would not expect any "consumer" microscope to achieve a resolution of 0.2 microns, but a high-quality laboratory microscope probably can get close.

180 - 7 Microns: Diameter of human hair. en.wikipedia.org/wiki/Hair

100 Microns: Approximate thickness of paper (copier paper of weight 24 lbs; 500 sheets is about 2 inches thick).

16 Microns: Thickness of household aluminum foil. en.wikipedia.org/wiki/Aluminum_foil

25.4 Microns: = 0.001 inches (1.0 mil). Standard resolution for an imperial caliper.

2.54 Microns: = 0.0001 inches (0.1 mil). Standard resolution for an imperial micrometer.

0.75 - 0.38 Microns: Wavelength of visible light. en.wikipedia.org/wiki/Visible_light

0.4 Microns: Sharpness of a modern razor blade. www-archive.mse.iastate.edu/fileadmin/ww...even/KnifeShExps.pdf

0.2 Microns: Resolution limit of optical microscopes. www.microscopyu.com/articles/optics/objectiveproperties.html

0.05 Microns: Sharpness of diamond coated razor blades. www.technologyreview.com/computing/25988/

0.005 Microns: Sharpness of a diamond microtome knife. www.tedpella.com/diamond_html/diamondk.htm

0.003 Microns: Sharpness of concoidally fractured obsidian. en.wikipedia.org/wiki/Obsidian

0.003 microns: Distance between a hard drive head and the spinning platter. en.wikipedia.org/wiki/Disk_read-and-write_head

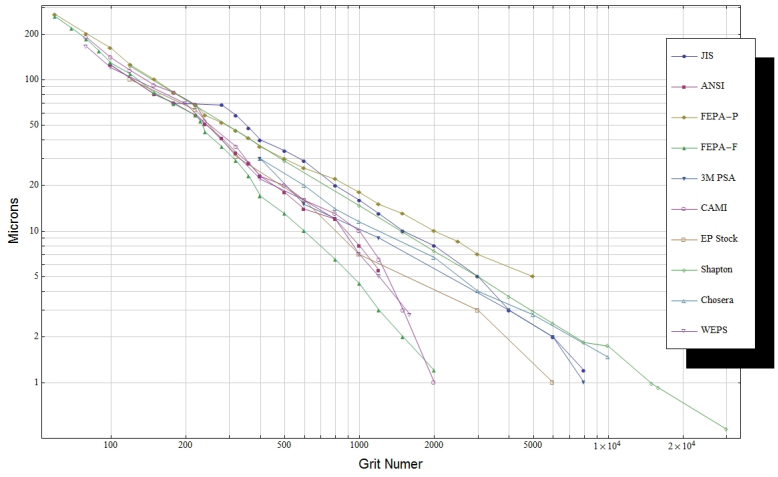
0.00034 Microns: Van Der Waals diameter of a single carbon atom. en.wikipedia.org/wiki/Van_Der_Waals_Radius

The needles used in scanning-tunnelling-electron-microscopes (STEM) and atomic-force-microscopes (AFM) are so sharp they literally have a single atom at their tips.

Also, x-ray telescope mirrors are atomically smooth. www.mpe.mpg.de/xray/wave/technologies/mirror.php

This is also fairly interesting when combined with Komitadjie's Grand Unified Grit Chart, which is an approximate conversion between sharpening stone grits and microns. The graph below is made by Mr. Wizard who used the data compiled by Komitadjie.

www.knifeforums.com/forums/showtopic.php?tid/904090/tp/7/



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