# A theory of how the WE diamond pastes work

Posted by mark76 - 01 Apr 2012 15:06

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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 wickededge - 01 Nov 2012 10:30

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**mark76 wrote:**

**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).

I've found horse leather to be very abrasive compared to cow which is abrasive compared to kangaroo. I'll have to do a whole separate study on that...

Below is the image with the cow leather again - there definitely is some minor abrasion, which I've circled. It doesn't show up so much on a really rough surface as it does when the metal is already well polished.

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# Re: A theory of how the WE diamond pastes work

Posted by AnthonyYan - 01 Nov 2012 17:55

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Hi Clay,

It'll be awesome if you get to collaborate with an SEM lab at Sandia National Labs! 😊

Right now, I don't have solid ideas about what experiments to do for an SEM, but if I think of anything, I'll be sure to let you know.

Here are three half-baked ideas:

(1) General strategy: Using your metallographic microscope, come up with some theories about what is happening, and also what your microscope cannot see (because of optical limitations). Then use SEM to test theories, and see what you couldn't see.

(2) A common technique when sharpening with stones is to use strokes that are 45 degrees from the knife edge. There are two directions for this, which are 90 degrees apart. So you can use one direction for a grit, and then when you go to the next finer grit, you can sharpen in a direction 90 degrees from the previous scratches. That way you can more easily see when you've removed all the scratches of the previous grit. I think you've mentioned this a few times.

Are we applying this to stropping? Sharpen with a stone in one direction, then strop in a direction perpendicular to the scratches from the stone. If there is burnishing, this might make it easier to see? Perhaps you are doing this already?

(3) How about traditional burnishing? Sharpen a knife with a stone, then burnish it with a hard smooth piece of metal. This could be a knife steeling-rod, a burnishing tool, or maybe even a ball bearing? Then examine it under the microscope (before and after). Not sure what this would tell us, as it is likely to be a very different kind of burnishing. But maybe it would be interesting and informative anyways?

Hi Philip,

What do you think would be a good experiment to test if burnishing is happening during stropping? Even if we couldn't perform the experiment, maybe people at Sandia could?

Sincerely,

--Lagrangian

P.S. Clay mentioned Sandia here:

www.wickededgeusa.com/index.php?option=c...8&Itemid=63#6643

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# Re: A theory of how the WE diamond pastes work

Posted by AnthonyYan - 01 Nov 2012 18:03

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Hi Clay,

I'm no expert on leather, but here is what I've heard here and there on various forums:

(1) Some leathers contain silicate particles (basically glass). Some speculate that the silicates are abrasive enough for stropping with plain leather.

(2) Leathers can be tanned in different ways. There is vegetable tanning, and then there are chromium and other tanning methods. I have no idea if these affect the abrasiveness of the leather, if at all. I think vegetable tanning is recommended for strops and sheaths because the chemicals used are not corrosive for metal, but the other tanning methods have chemicals that could cause corrosion or patina.

I don't have any definitive references for either of these. So just take them as hear-say!

Sincerely,

--Lagrangian

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# Re: A theory of how the WE diamond pastes work

Posted by razoredgeknives - 01 Nov 2012 18:11

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Clay, just wanted to say thank you so much for what you're doing! This is definitely the best forum out there that I've found... Loving the research, constructive criticism and "debate" 🙂 keep it up guys! I just haven't chimed in because I don't have much to add, lol, as I'm no engineer... But I'm learning a ton!

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# Re: A theory of how the WE diamond pastes work

Posted by PhilipPasteur - 01 Nov 2012 18:13

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**AnthonyYan wrote:**

Hi Clay,

Hi Philip,

What do you think would be a good experiment to test if burnishing is happening during stropping? Even if we couldn't perform the experiment, maybe people at Sandia could?

Sincerely,

--Lagrangian

That is a good question. I will have to think about it. To be honest, I have usually left testing methodology up to hose that have more imagination than myself. This includes both materials and software testing. I need to sit down and do some sharpening for a few hours...maybe something will come to me..

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## Re: A theory of how the WE diamond pastes work

Posted by AnthonyYan - 03 Nov 2012 06:21

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Hi Everyone,

I thought it might be worth excerpting part of Prof. John Verhoeven's work on stropping. This is from his technical report,_Experiments on Knife Sharpening_ which is free to download here:

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

Verhoeven had a hypothesis about stropping, which he then tested experimentally, and we can compare notes to Clay's microscope images.

On page 19, Verhoeven states his hypothesis:

"It was the opinion of the author at the start of these experiments that clean leather strops would contain sufficient levels of natural abrasives adequate to produce significant improvements in the edge quality. Therefore experiments were done initially on clean leather strops. This was followed by experiments done on leather strops coated with a thin layer of honing compound."

To test this hypothesis, he used a scanning electron microscope (SEM) to image the knife edge. Verhoeven's images come in triples:

(1) The first image is straight into the edge of the knife. That is to say, figuratively, the knife edge would cut your eye.  SEM's have insanely huge depth of focus, so despite this view, the entire field of view is in focus! This view allows you to see both bevels and the apex itself.

(2) A side view of the "top" bevel.

(3) A side view of the "bottom" bevel.

So was Verhoeven's hypothesis correct?

Here are the results before and after stropping:

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Before:

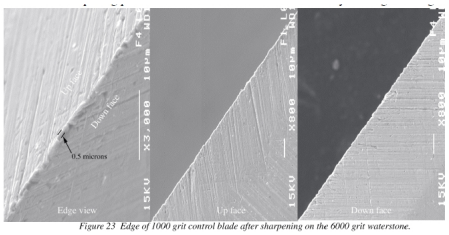

*Figure 23  Edge of 1000 grit control blade after sharpening on the 6000 grit waterstone.*

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After:

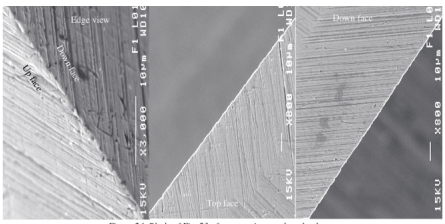

*Figure 24  Blade of Fig. 23 after stropping on clean leather.*

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Verhoeven's concludes his hypothesis was wrong:

"The stropping action on the clean leather does not appear to have had much effect on the condition of the as-ground edge. The bur shown in the edge views may be just a bit smaller, but it is only a minor effect. The abrasive grooves along the faces appear to be little affected by the action of the stropping. This result is typical of what was found on additional experiments using the second clean leather strop described above. Experiments with clean leather stropping of blades prepared on 600 grit wheels showed that the clean strop was not effective in removing the larger burs formed on the 600 grit wheels."

Compare this to stropping with compound.

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Before:

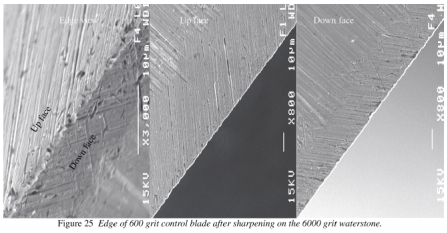

Figure 25 *Edge of 600 grit control blade after sharpening on the 6000 grit waterstone.*

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After:

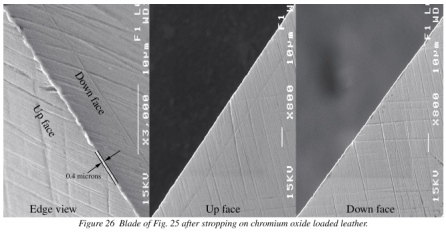

*Figure 26 Blade of Fig. 25 after stropping on chromium oxide loaded leather.*

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Verhoeven concludes:

"The chrome oxide abrasive used on the blade of Fig. 26 has produced a dramatic reduction in the size of the remnant abrasive grooves on the face of the blade. As shown in the edge view of Fig. 26 the bur width is on the order of 0.4 to 0.5 microns."

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So far, if you look at Clay's results, they seem to me, to be similar to Verhoeven's. To my eye, Clay's results with plain leather, or plain leather plus alcohol, show minor changes. But when compound is used, the effect is easily visible. It will be interesting to see Clay's results after he gets the plain paste.

One must keep in mind this is not an apples-to-apples comparison, because we don't know the differences between Clay's stropping procedure and Verhoeven's. Even so, the similarity between Clay's and Verhoeven's results is reassuring to me.

Sincerely,

--Lagrangian

P.S. Clay, your images are great, and thanks for all the experimenting!

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## Re: A theory of how the WE diamond pastes work

Posted by cbwx34 - 03 Nov 2012 09:40

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I've stropped with plain leather on a belt sander... if the edge is properly created... even with this amount of power stropping, you'll see little, if any difference. My opinion is that the issue sometimes becomes confusing because edges aren't properly sharpened to begin with, the leather is then used to correct the mistakes. For example, if a burr is left on the edge, plain leather may eliminate some of this... the conclusion is then made that plain leather improves the edge. It did, but not for the reasons thought.

Anthony, your posts are great... need to get you working on the Wiki!

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# Re: A theory of how the WE diamond pastes work

Posted by PhilipPasteur - 03 Nov 2012 10:08

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I agree Anthony, great post. I would love ot have you come up with some things for the WIKI.

One thing to remember, however, this latest set of tests that Clay has been doing, was to try to capture some evidence of burnishing with strops. The primary focus, or so I interpreted it, was strops with compound. He then progressed to some other scenarios, I think to try to set some kind of baseline. If we are getting burnishing, what combination of materials will begin to cause it?

BTW, Anthony, I have read the article that you cite a few times, but don't have it in front of me. Does he mention the specific kind of leather and how it was tanned, for the sample he used?

I am curious because, though intuitively, to me, his results make perfect sense, they fly in the face of all of the straight razor users that insist that stropping on plain leather makes a significant difference in their edges.

Phil

**AnthonyYan wrote:**

Hi Everyone,

One must keep in mind this is not an apples-to-apples comparison, because we don't know the differences between Clay's stropping procedure and Verhoeven's.  Even so, the similarity between Clay's and Verhoeven's results is reassuring to me.

Sincerely,

--Lagrangian

P.S. Clay, your images are great, and thanks for all the experimenting!

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## Re: A theory of how the WE diamond pastes work

Posted by AnthonyYan - 17 Nov 2012 11:22

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I'd love to help with the wiki.  A bit busy, but I'll find some time!

If nothing else, I would like to help with the list of "Sharpening Length Scales."

Sincerely,

--Lagrangian

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## Re: A theory of how the WE diamond pastes work

Posted by JacobWilson - 08 Apr 2013 21:06

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WOW! Just spent 2 hours reading through this thread. My mind is blown.

I had some thoughts/requests. I'm no expert by any means. Just learning and thinking.

I'd love to see some updated pictures of the results of Roo & Nano with the added magnification. It seemed that at 510x the steel was so smooth. I'm wondering what the abrasions look like under 2000x+ magnification and how smooth the steel really is.

I was also wondering if the backing of certain leathers produce different results. Since the regular cow strops are composed of thicker slices than the Roo, could the 'give' of the cow leather produce different sorts of abrasion or burnishing than the thinly sliced Roo on aluminum? I would think the toughness of thin Roo on aluminum backing would create a much different 'scratch' or 'smear' than cow with give. It'd be interesting to see samples of thinly sliced cow on aluminum backing up against Roo on the same. Maybe the give of the cow leather allows the inherent abrasive quality of the media to be more present, while the stiffness of Roo allows the diamonds to do most the work.

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