Dendritic Instabilities

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Flow Visualization MCEN 4151
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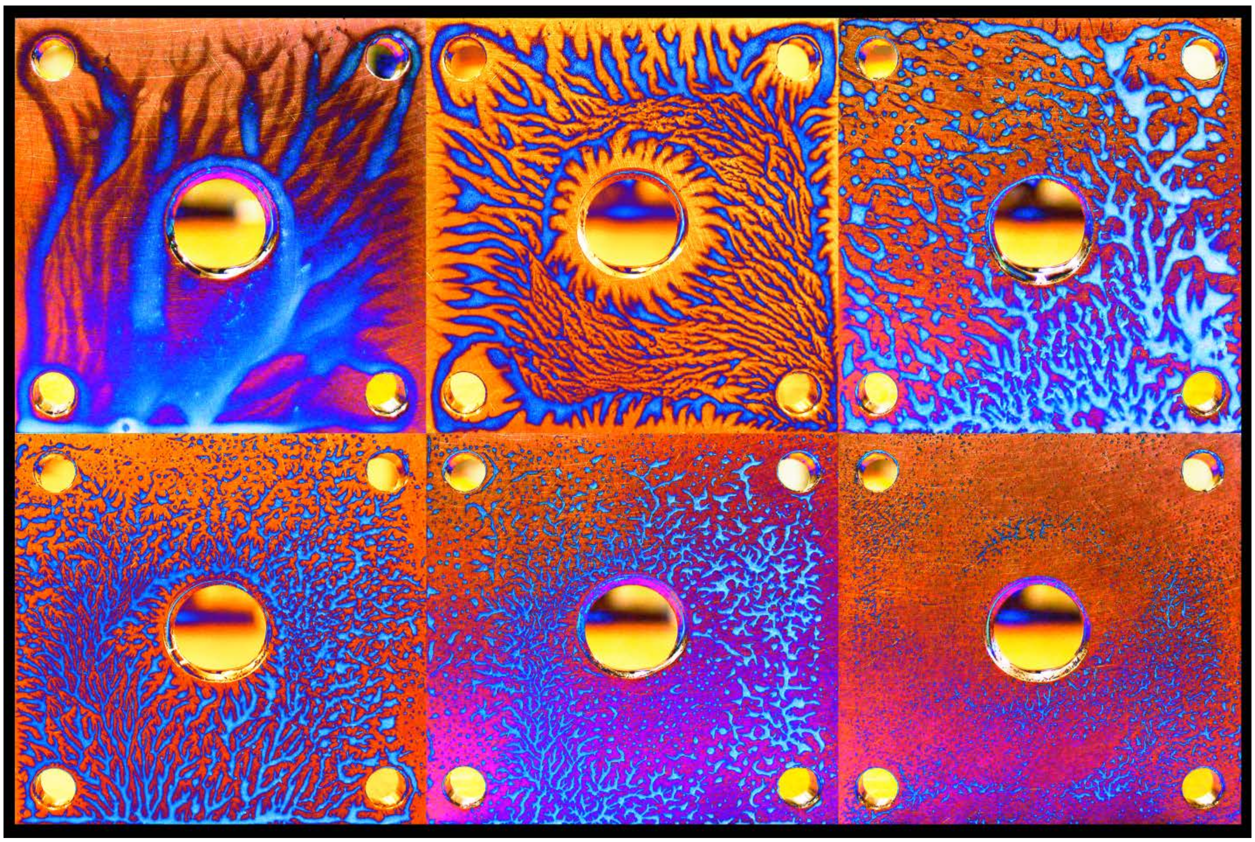

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Introduction:

Interesting fluid dynamics sometime surprise us in sneaky ways. While wet sanding an aluminum part in the machine shop, I noticed a very intricate and ever changing pattern every time I lifted it. One of the shop guys informed me that what I was witnessing is called dendritic fingering. The intent behind this compilation of images is to show a verity of possible patterns by varying the amount of honing oil and sanding.

The Set-Up and Physics:

These images were taken while sanding a two inch square piece of 6061 aluminum on 400 grit silicon carbide sand paper held on a steel flat plate with magnets. The sanding started with an excess of honing oil moving in a figure eight. The part was lifted in no special manner. After each photo some of the oil was blotted off the sand paper and the grit was left to thicken. This effectively raised the viscosity.

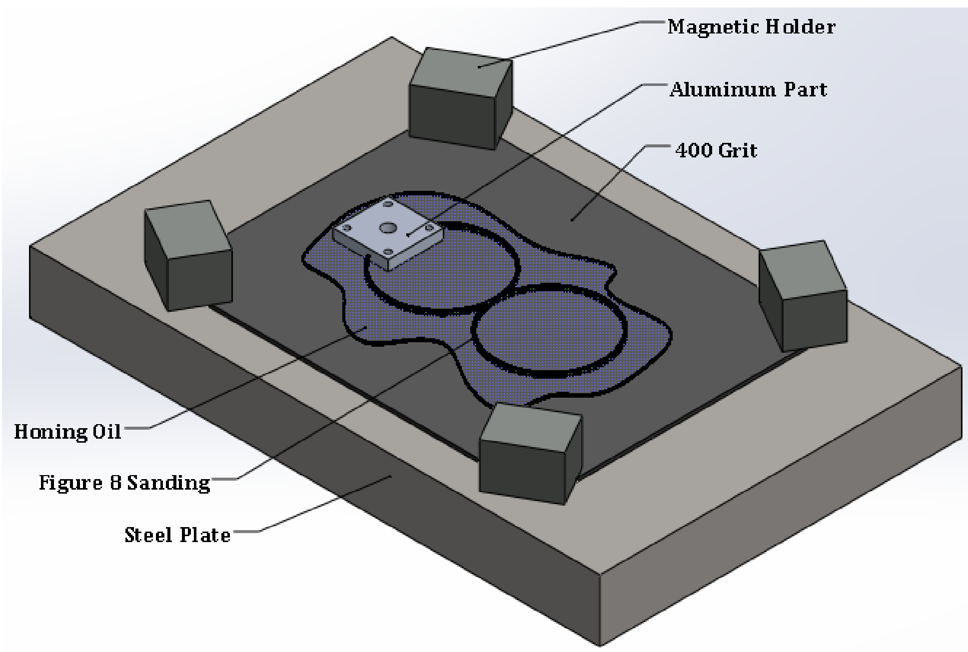

Figure 1: Sanding Set-Up and Procedure

The physics governing the formation of this pattern is viscous fingering. This occurs any time a less viscous fluid is forced to mix with a more viscous fluid. In this case air was forced to mix with the oil as the part is lifted. As the fingers grow they should coalesce to for one large finger referred to as the Saffman-Taylor Finger. Mathematically viscous fingering can be described by Darcy's Law (a derivative of the Navier-Stokes equation). The fingers are dependent on the velocity of the plate, gap width between the plates, viscosity, and pressure. Any flow between parallel plates like this is Hele-Shaw flow.

Visualization Technique:

No special fluid visualization techniques where used to get the original images. The automatic camera setting captured sharp enough images. The Photoshop curves feature was used to increase the visibility by inverting the upper and lower range values. Then the image was cropped and stacked with others for variety.

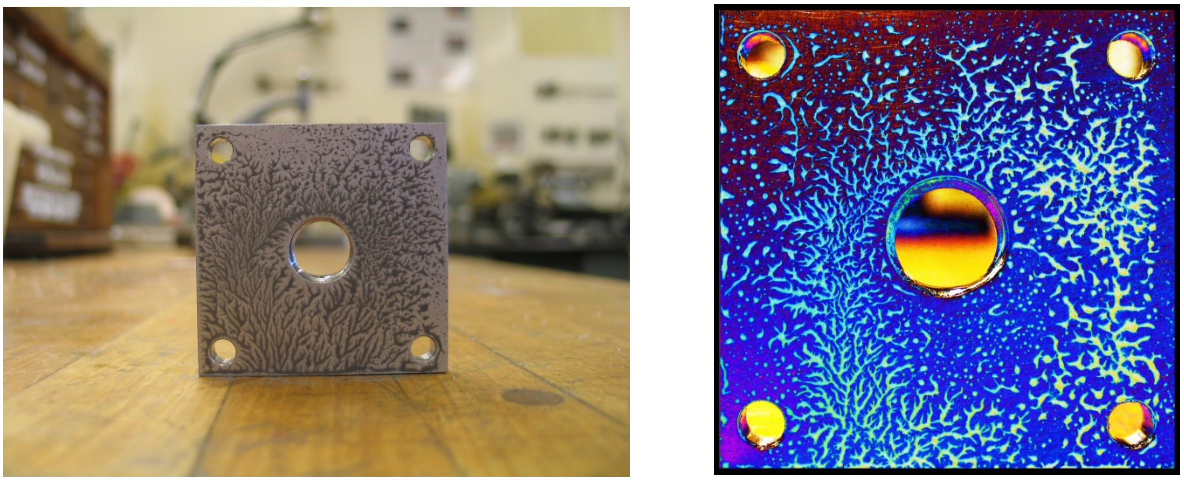

Figure 2: Unedited Photo (Left) and Processed Image (Right)

Date: 3/9/2013	Resolution unit: 2	Exposure time: 1/20 sec.
Dim: 2592 x 1944 pixels	Colors: RGB	Focal length: 7mm
Resolution: 180 dpi	Cam: Canon PowerShot G5	Aperture: 2
Bit depth: 24	F-stop: f/2	Flash: none

Commentary:

I had some fun playing with curves in Photoshop to get the psychedelic color scheme. There is a lot to grab your attention with hoe the fingering changes near holes and with different viscosities. It is meant to be busy some more runny, gritty, or intricate. If this project were to go further I would want to explore how the pattern changes in response to other obstacles such as oddly shaped holes.

Source:

Saffman, P.G. "Vicous Fingering in Hele-Shaw Cells." Journal of Fluid Mechanics 173 (1986): 73-94. Web. 20 Mar. 2012.