

## ***Micro-Hardness Testing of Heat Affected Zones***

Welding is the process of joining metals together so as to ensure the continuity of the assembled material. This is usually done by melting the metals and adding a filler material to form a pool of molten material, called a weld pool, which eventually cools, forming a strong joint. Different sources of energy are used for welding, such as gas flame, electric arc, laser, and friction.

Joining metals together by welding is a skill which demands precision and expertise. One must know that the quality of a weld is dependent on the combination of materials used for the base and the filler material. Not all metals are suitable for welding, and not all filler materials work well with acceptable base metals. Even when base material and filler material are complementary, the weld can be subject to detrimental effects due to the welding process itself.

The microstructure of the base metal is always altered by the fusion of its substance. Heat generated by the energy source, followed by the subsequent re-cooling of the material causes changes in the area surrounding the fusion zone. This changed area, also called the heat-affected zone (HAZ) can be of varying size and strength. In general, the extent and magnitude of the HAZ is inversely proportional to the diffusivity and cooling rates of the material, i.e. where thermal diffusivity is high, the material cooling rate is high and the HAZ is small; where thermal diffusivity is low, the cooling rate is slower and the HAZ is larger.



**Fig. 1:** Schematic of a weld.

In the above schematic (Fig. 1), the dark gray represents the weld or fusion zone, the light gray represents the base material, and the medium gray is the heat-affected zone. In fact, the HAZ is a portion of the base material that has not been melted, but whose mechanical properties have been altered by the heat of the welding process. Understandably, this alteration can be detrimental, causing stresses that reduce the strength of the base material, leading to catastrophic failures. That is why weld-testing is an essential part of quality control.

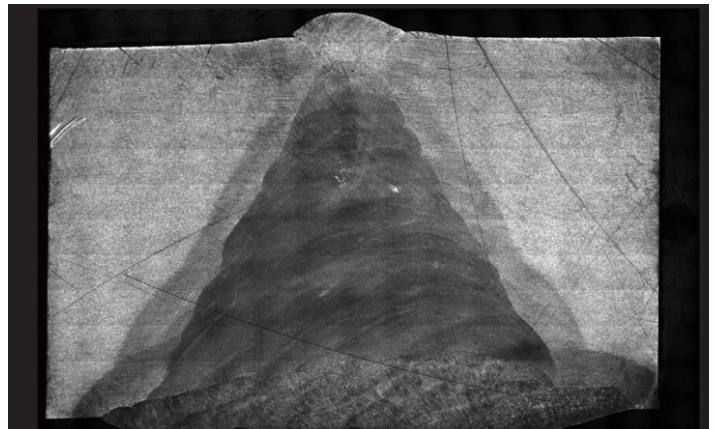
Weld-testing comes in two forms: non-destructive methods such as acoustic impact techniques that detect the presence of cracks, and destructive methods, where a weld specimen is subjected to a series of stress tests that ultimately bring about its destruction. Destructive testing is easier to carry out, and yields more easy-to-interpret information than non-

destructive testing. For welds, micro-hardness testing is an easy way to measure a specimen's ability to resist plastic deformation from a standard source.

In the following example, indents are placed on a weld sample whose HAZ is clearly visible thanks to the new Clemex CMT.HD using its Mosaic Image capabilities.

### **The Steps**

Using the Mosaic Image command in Clemex CMT.HD, 182 images are grabbed automatically and stitched together, forming a 13x14 image of the entire sample. Seeing the sample as a whole, the fusion zones and the HAZ are clearly visible and distinguishable from the base material, even with a scratched surface (Fig. 2).



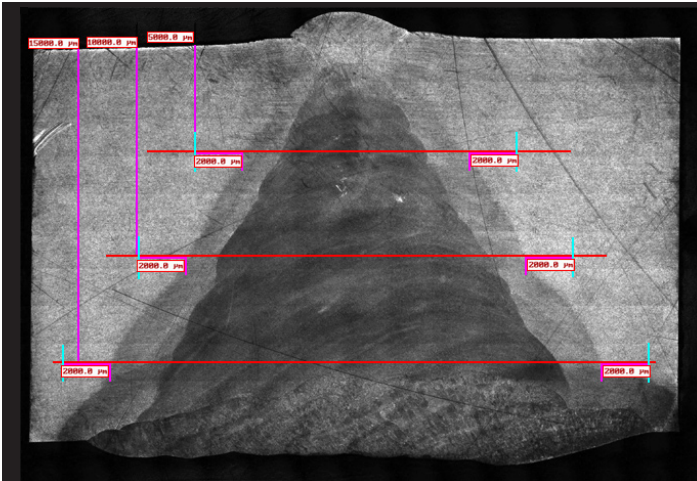
**Fig. 2:** Mosaic image of complete sample.

In this case, we must indent the sample at three different depths. Using the software's Annotation Tools, and with the Mosaic Image created, it is easy to draw different path lines that will ultimately determine where the traverses will be positioned.

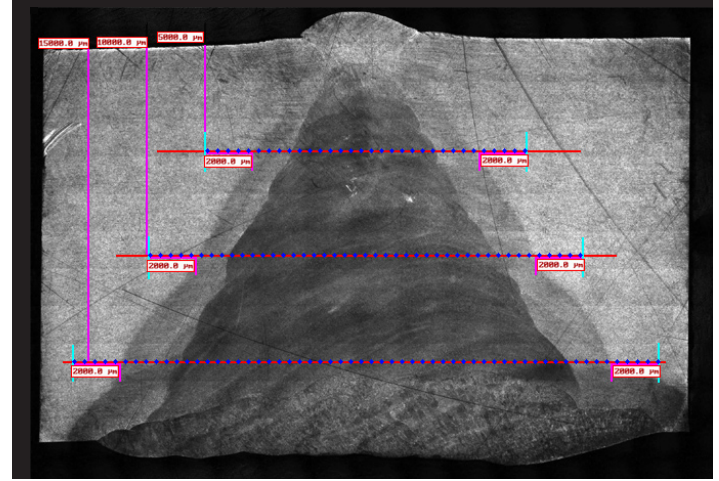
The line tool, that conveniently show the distance in microns as the line is drawn, allows us to draw three "depth lines" starting from the exterior part of the sample, to depths of precisely 5000, 10000, and 15000 microns. From those, a series of perpendicular lines are drawn that will determine the paths of the traverses (Fig. 3).

Thanks to the mosaic image, it is now easy to draw a traverse starting point at exactly 2000 microns from the Heat Affected Zone into the base material. No other software allows this kind of precision.

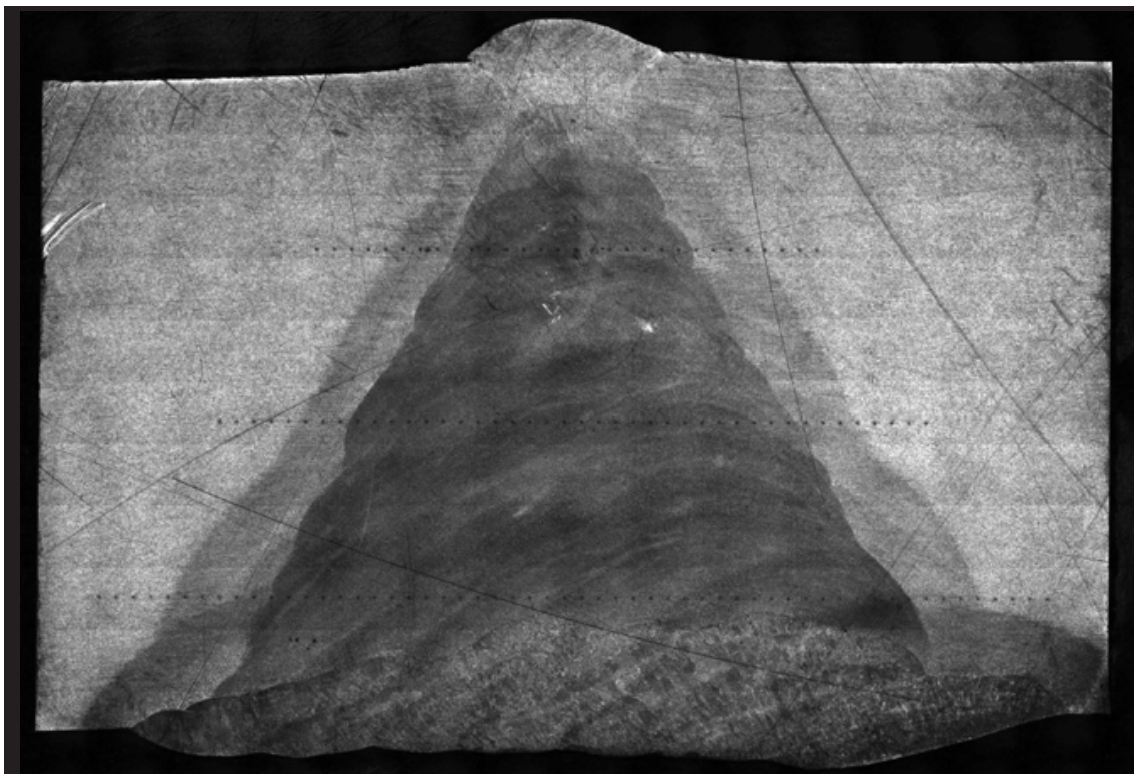
Once the layout is drawn, the image is transferred in the Stage Pattern Window. It is here that the spacing between indents is determined and the traverses correctly positioned (Fig. 4). The automated indenter then follows the path of the traverse patterns to test the sample's material hardness (Fig. 5).



**Fig. 3: Step 1:** Straight lines drawn to determine depth. **Step 2:** Red lines indicate the traverses' paths. **Step 3:** Distance of 2000.0 microns from the edge of the heat affected zone into the base material. **Step 4:** Cyan lines drawn to indicate the beginning and the end of each traverse.



**Fig. 4: Traverses (in blue) placed.**  
Traverse 1: 30 indents,  
Traverse 2: 42 indents  
Traverse 3: 56 indents.



**Fig. 5: Sample has been indented following the guide drawn before hand.**

