

Surface Finish after ED-Machining

Although surface quality can be measured, in real life it is more often estimated, mainly because of the high costs of the required measuring equipment. In case of EDM'd work pieces, both wire cut or spark eroded, values given by the machine manufacturer are often taken for granted. Especially in the case of EDM'd surfaces, there is however more to surface quality than just a simple Ra or VDI value. Like every other non-conventional machining method, EDM also has an influence on the surface integrity, which in some cases has an even bigger influence on the quality of the work piece than the roughness. So what surface quality can be achieved using the EDM process, and what influence does it have on the surface integrity of different materials?

Surface Integrity- Surface Roughness

While surface roughness can be measured comparatively easily, surface integrity requires some more complex analysis. Surface roughness is generally measured in $\mu\text{m Ra}$,

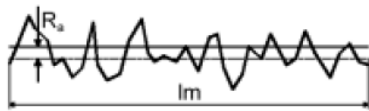


Figure 1

which means the "arithmetic mean roughness" (Fig 1), occasionally in

Rz, which means average "peak to valley" roughness (Fig 2). It does not say anything

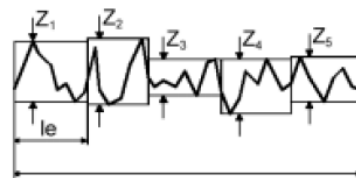
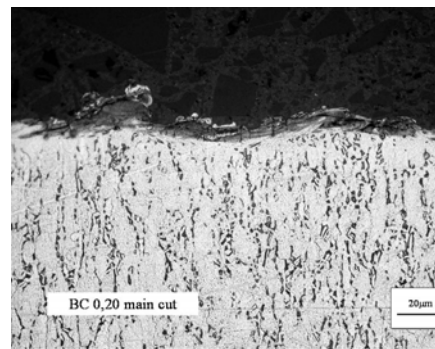


Figure 2

regarding the quality of the measured surface, which is particularly important after a machining process such as EDM.

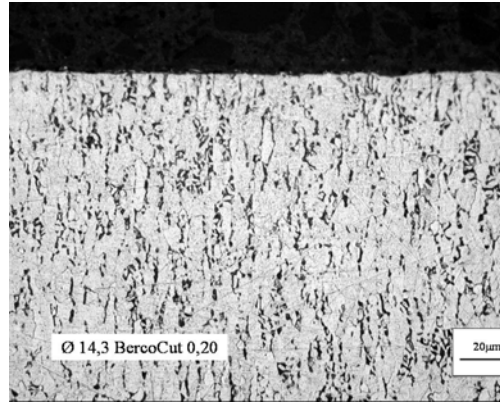
During erosion, a spark jumps across the gap between electrode and work piece, which is known as a discharge, and in the process electrical current is converted into heat. The heat is so intense, although on a microscopic scale, and the work piece material evaporates almost instantly, creating a small crater. At the bottom of this crater, a thin layer of material is molten but not removed from the work piece by the time the electrical pulse is terminated. This layer, once cooled down, forms what is known as a re-cast layer. In figure 3 the re-cast layer after wire cutting (one rough cut with maximum power) can be seen quite clearly. The material properties of this layer are obviously different from the properties of the base material and the effect of the melting and re-solidifying varies significantly between different materials. In general, the re-cast layer is a lot harder than the base material and usually has micro cracks. In addition, the bond between base material and re-cast layer is often not very strong.



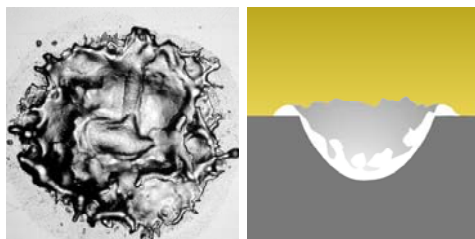
Picture 3

When trim cuts are executed in wire cutting, or one or more finishing electrode is used in die sinking, the heat affected zone on the surface of the work piece can be reduced dramatically, in general to a point where the thickness of the influences layer becomes academic. Picture 4 shows a magnified cross

section of the same work piece as picture 3, but after trim cuts! The heat affected zone or re-cast layer was basically completely removed during the trim cut with appropriate generator settings. Advanced generator technology, as is standard in all GF AgieCharmilles machines, reduces the build up of a re-cast layer already in the main cut. In order to achieve that, the pulse control has to be very sophisticated – and fast! On new GF AgieCharmilles generators, every single pulse is individually controlled to avoid “cooking” of molten material for any length of time. As a result, the crater



Picture 4

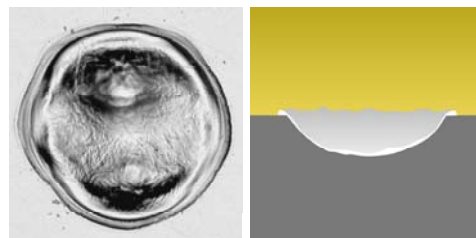


Picture 5

generated during erosion has a smooth surface and the re-cast layer is for most purposes insignificant. Picture 5 shows the effect of a single EDM pulse from a standard generator on a work piece, while shows the effect a pulse from a state

of the

art GF AgieCharmilles generator. It is obvious that with a sophisticated generator, better results can be achieved with less cuts, or electrodes in case of die sinking, saving machining time and money!



Picture 6

At the same time, the building of micro cracks, which can lead to premature failure of EDM'ed parts, can be largely avoided.

What can realistically be achieved?

For Wire EDM, a roughness of an $Ra < 0.15\mu m$ is realistic, although it will require a state of the art machine and, depending on the work piece material and the EDM wire used, up to seven cuts might be necessary. It has been shown that cutting tools or drawing dies for instance, when EDM'd to the best achievable quality, had an up to five times increased tool life!

In Die Sinking, the surface roughness of the electrode has initially the biggest influence on the surface roughness on the work piece. While orbiting can improve the result slightly, it is still basically a mirror image of the electrode that is produced on the work piece. Using advanced milling technology such as high speed milling, it is possible to produce electrodes with an Ra of $< 0.20\mu m$, which in turn makes it possible to achieve an Ra of approximately $0.15\mu m$ using a state of the art Die Sinking EDM machine. If the surface roughness of the EDM'd work piece is of a lower quality than that of the electrode, then the machine, or more precisely the generator, is clearly of a very low quality.

If you would like to discuss this topic in more details, or if there is a specific application you would like to discuss, please do not hesitate to contact us anytime.