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Laser Beam Texturing Produces Superior Matte Finishes for Metal Forming Applications

In the majority of metal drawing and forming operations, the metal utilized is imparted with a surface texture designed to aid forming. This surface texturing, which is typically imparted as a matte finish, is present primarily to improve the drawability of the metal by providing depressions in the surface to increase the lubrication carrying capacity of the metal to be formed. Additionally, these types of textured finishes may be used to promote paint adhesion and/or for enhanced appearance of the final formed component.

In North America, almost all textured or matte finishes are developed through either mechanical means (shot-blasting, grit-blasting, grinding) or electro-discharge texturing (EDT) of the surface of mill rolls that then impart the developed finish onto the surface of the metal during the final rolling operation.

In Asia and Europe, in addition to the methods outlined above, a different set of processes for creating a textured finish have been developed using laser beam texturing (LBT) or electron beam texturing (EBT) systems to impart a matte finish to the mill rolls. These systems, for the reasons discussed below, have been found to provide a finish that offers pronounced advantages over the more traditional methods of creating a matte finish via shot- or grit-blasting, grinding or electro-discharge texturing (EDT). This article focuses on laser beam textured (LBT) product and how it differs from material produced using "traditional" surface texturing techniques.

Importance of Matte/Surface Finishes

Lubrication, in conjunction with die design and material selection, is one of the most critical factors in forming and drawing of flat rolled steels. The lubricant, typically an oil, is applied to the surface as a means of reducing friction during the forming and drawing process. The surface topography of the steel has a large impact in determining how effective the lubricant will be during the forming process. To be effective, the imparted matte or textured surface finish should be consistent in surface characteristics across the width as well as down the length. It should allow for even and consistent contact pressure over the entire part, enhancing metal flow during the forming operation and preventing localized strains leading to metal failure.

By maintaining consistent lubrication, the potential for negative and undesired outcomes during the forming and drawing operation are greatly reduced. These issues include, but are not limited to:

- ***Die Damage –*** Excessive die wear and/or galling can occur due to localized strains, resulting in higher die maintenance costs.
- ***Product Loss –*** Galling and damage to parts can reduce yields and increase inspection costs.
- ***Production Delays –*** Extra time needed to service dies worn prematurely and to make up for scrapped parts.
- ***Unhappy Customers –*** An outcome resulting from part variability, delivery and low yields.

Why is a Laser-Beam-Textured (LBT) Finish Advantageous over Other Types of Matte Finish?

In order to adequately compare surface characteristics of various types of finishes, it is necessary to look beyond normal profilometer traces. While information provided via a standard profilometer trace indicates surface roughness with several other parameters available, each test is a single trace across the surface. 3-D imaging, available through light interference technology, provides a tool for more refined analysis over a much larger surface area, providing a truer picture of the topography of the material. This technology is a key component in quantifying the notable differences in the various types of matte finishes detailed in this article.

As stated, the most common methods of texturing the surface of flat-rolled products in North America have been through shot- or grit-blasting, grinding and electro-discharge texturing (EDT) of the mill rolls used in final rolling of product. Shot- or grit-blasting is performed by propelling a quantity of abrasive media at the roll surface, at high speeds, upsetting the surface and producing a roughened texture or matte finish. This method, by nature, produces a somewhat non-uniform and variable finish. Figure 1 shows the 3-D surface of steel produced from blasted finish mill rolls as compared to the steel surface in Figure 2, produced by EDT processed mill rolls. Electro-discharge texturing (EDT) involves the application of a pulsed electric field between a tool electrode and work roll, which results in tiny random sharp craters in the surface.

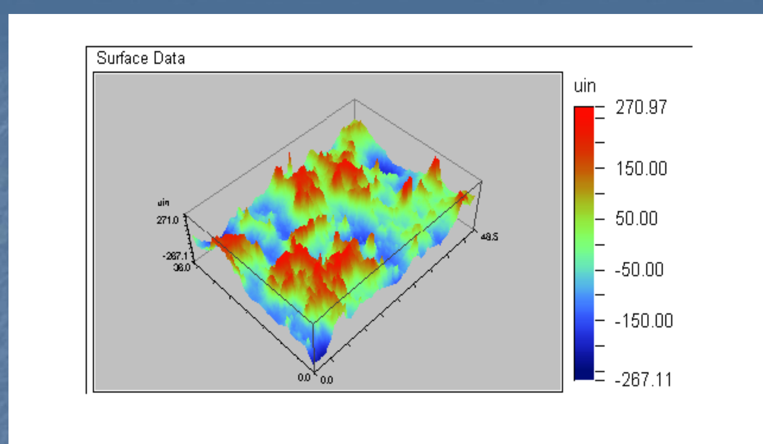

Figure 1. Blasted Surface Finish in 3-D

Note: In the 3-D images, the red indicates height and the blue indicates depth.

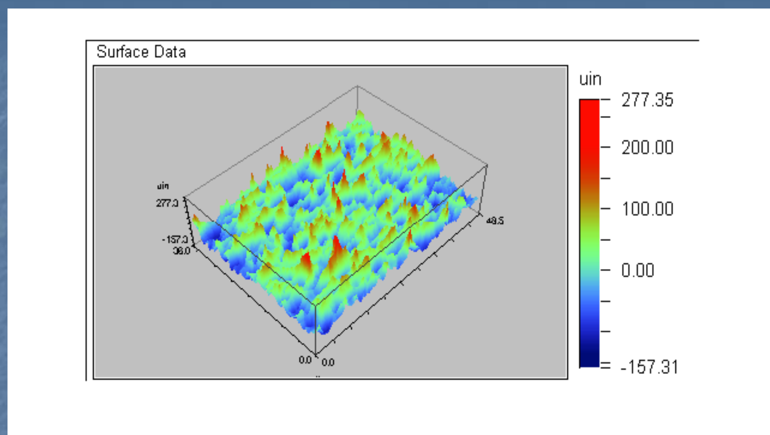

Figure 2. Electro-Discharge Textured Surface in 3-D

As the 3-D images show, the blasted surface exhibits greater variability than the EDT steel surface. It should be noted that both types of surfaces exhibit pronounced peaks on the surface of the material. Due to their profile, these pinpoint peaks are prone to breaking and/or deforming during the forming and drawing process and can lead to galling, premature tool wear and die lube contamination. As a point of reference, it is generally accepted that of the two finishes detailed, the EDT surface is the more consistent of the two traditional matte finishes.

Ground finish, provided by using grinding wheels or abrasive media, is also a method used to produce a roughened surface finish to enhance retention of die lube. While this method provides for a surface with an increased surface roughness, the properties of the surface are unidirectional and exhibit notable differences in the longitudinal and transverse directions, making it unacceptable for most drawing applications. Figure 3 shows the general appearance of steel rolled with ground rolls.

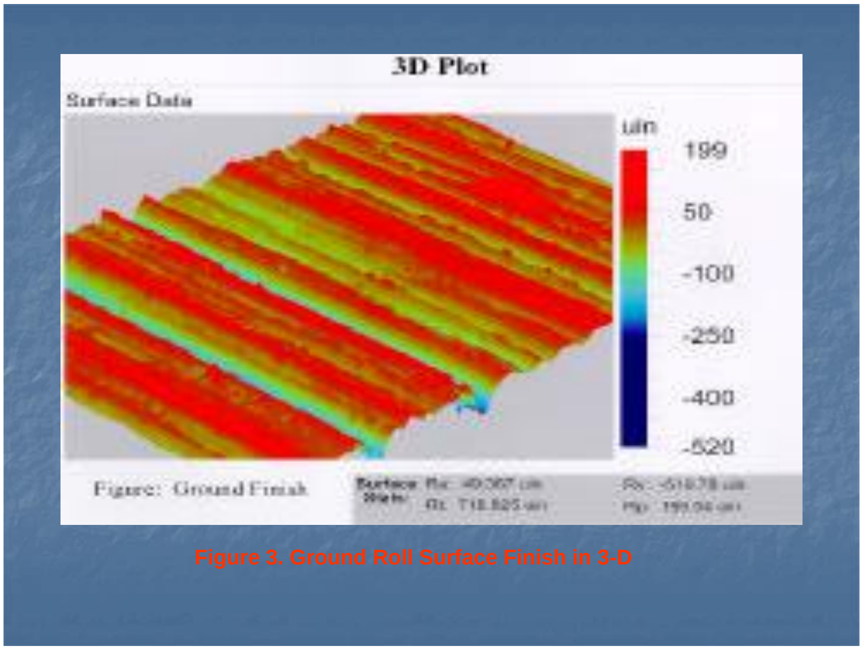

Figure 3. Ground Roll Surface Finish in 3-D

In examining the above surfaces, it becomes apparent that aside from the variability, one of the key issues with shot- or grit- blasting and EDT processed material is the presence of the small pinpoint peaks, which tend to break off and deform early in the forming operation, leading to potential draw inconsistency, galling and die wear. The ground finish typically does not have the pinpoint peaks of a blasted or EDT finish, however, it is uni-direction and thus problematic for most drawing and forming operations.

An appropriate method to take into account when analyzing the peak formations on material surfaces is to measure the “skewness” of the surface. “Skewness” of the surface compares the relationship of “peaks” and “valleys” on the steel surface. If a surface is skewed toward the positive side, there is more “peak” than “valley”. If skewed negatively, there is more “valley” than “peak”. Figure 4 shows a profilometer trace of both of these surfaces, as well as a “neutral” surface (equal peak/valley distribution).

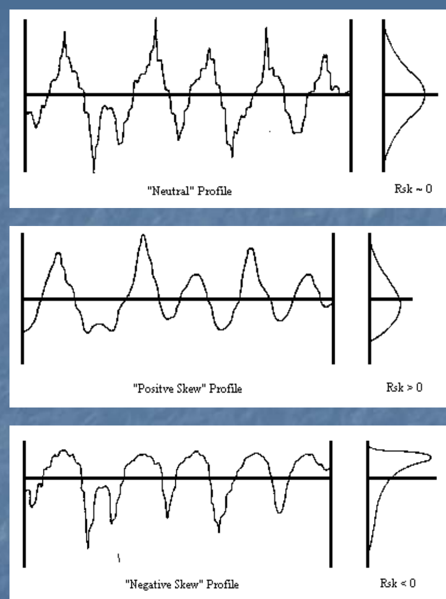

Figure 4. Surface Texture Skew Is Extremely Important

Material imparted with a laser beam textured (LBT) surface inherently exhibits a "negative" skew, while those produced with "traditional" finish methods tend to exhibit a "positive" skew. This difference in surface topography can be observed in Figure 5. This image shows material imparted with a laser beam textured (LBT) surface and the associated "negative" skew. Figure 6 shows an enhanced, higher magnification view of the LBT surface further demonstrating both the lack of pinpoint peaks that are undesirable in the forming and/or drawing process and the large surface bearing area provided by this type of finish.

In addition to the "negative" skew provided to material processed with laser beam textured (LBT) rolls, the technology imparts a deterministic finish verses the stochastic or "random in nature" surface that is imparted by normal "traditional" types of matte finish, lending to greater consistency and predictability during forming.

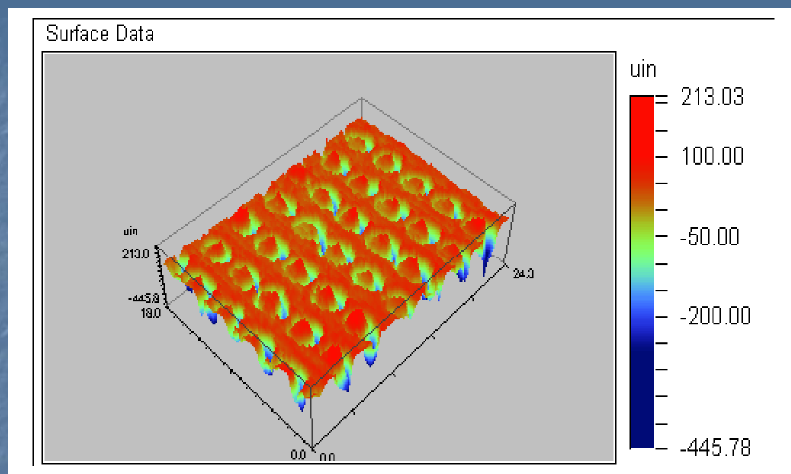

Figure 5. Laser Textured Surface in 3-D

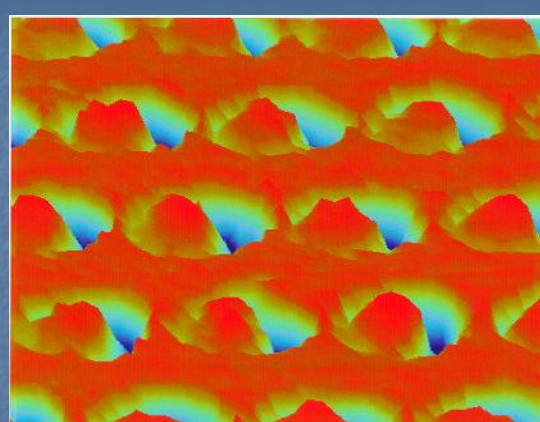

Figure 6. Laser Surface at High Mag. – 3-D

Laser Finish Benefits

State-of-the-art laser texturing, such as that which was developed in Japan and now is being produced as LaserMatte® by Greer Steel in North America, creates a uniform matte finish on the work rolls by consistently imparting micro-craters in the surface of the steel. These micro-craters produce a relatively large, negative skew (Rsk) material at typical Ra levels of 25 to 50 microinches (Figures 5 and 6), as compared with the positive skew pattern that is evident in the other matte finishes. (Greer Steel uses 3-D imaging to perfect surface finishes for its customers). This laser texture surface provides a microscopic lubrication distribution system on the metal surface that continually feeds lubricant in the die during forming.

The precision of the micro-craters is made possible by a 2.8kW CO2 laser that produces a microscopic beam of light energy that is interrupted by an aluminum chopper wheel. The wheel uses highly precise teeth to chop the beam into pulses. Each segment of light strikes the surface of the roll as it turns on a lathe, creating localized melting on the alloy surface. A blast of assist gas then displaces the molten metal, forming a surface feature similar to a volcanic crater. Uniformity and consistency are achieved by repeating the process 40,000 times a second in a helical pattern as the laser moves slowly along a track parallel to the turning roll. Millions of small craters are precisely placed on the roll surface, with their pitch and size controlled by a multi-axis regulator.

Laser texturing provides a highly uniform, precision metal surface topography that cannot be produced by conventional methods. The predictable and repeatable surface brings numerous benefits to metal formers that extend far beyond greatly improved lubricant-holding capabilities. The benefits in utilizing the laser-textured product include:

- Reduced friction and galling, resulting in improved part quality
- Longer tool and die life
- Improved process yield
- Avoidance of costly tool and die coatings
- Increased productivity due to reduced press downtime
- Improved metal flow in the die, as strains that cause breakage are prevented, thus allowing the metal to achieve its forming potential
- Lower energy costs achieved through greater process and production efficiencies

Surface finishes affect metal formability, lubrication retention, surface contact area, paint adherence, appearance and surface bonding area in metal forming. They also affect functionality and wear rates between mating surfaces in end-use applications. Achieving an optimum matte surface is a challenge, but laser texturing technology is providing metal formers with a reliable, cost-effective solution that brings immediate and long-term benefits with positive bottom-line results.

About the author: Todd Daenzer is Chief Operations and Quality Officer at Greer Steel Company, a leader in cold-rolled strip quality that operates its production plant and service center in Dover, Ohio. Greer Steel, founded in 1917, provides LaserMatte®, the most advanced surface texture available in North America that employs laser beam technology to create a microscopic lubrication distribution system