Laser Beam Texturing for Automotive Metal Forming Applications

An alternative to traditional surface texturing processes is laser beam texturing, which offers various advantages over other commonly used methods.

Importance of matte/surface finishes

Lubrication is a critical factor in forming and drawing flat rolled steels. Oil (the typical lubricant) is applied to the surface to reduce friction during forming and drawing. The surface topography of steel impacts the lubricant’s effectiveness during forming. The matte or textured surface finish should be consistent in surface characteristics across the width as well as along the length to be effective. It should allow for even and consistent contact pressure over the entire part, enhancing metal flow during forming and preventing localized strains that could lead to failure. Maintaining consistent lubrication greatly reduces potential problems during forming and drawing. Issues include:

- Die damage: Excessive die wear and/or galling occurs due to localized strains, increasing die maintenance costs.
- Product loss: Galling and damage to parts can reduce yields and increase inspection costs.
- Production delays: Extra time is needed to service prematurely worn dies and to make up for scrapped parts.

Advantages of laser-beam-textured finishes

In order to adequately compare surface characteristics of various types of finishes, it is necessary to look beyond traditional profilometer traces. While this information indicates surface roughness and other parameters, each test is a single trace across the surface. 3D imaging, available through light interference technology, allows for more refined analysis over a much larger surface area, providing a more accurate picture of the material’s topography. This technology plays a key role in quantifying the notable differences in the various types of matte finishes detailed in this article.

One common method, shot/grit-blasting, propels abrasive media at the roll surface at high speeds, which upsets the surface and produces a roughened texture or matte finish. This method produces a somewhat nonuniform and variable finish. Figure 1 shows the 3D surface of steel produced from blasted finish mill rolls as compared to the steel surface in Fig. 2, produced by EDT-processed mill rolls. EDT involves applying a pulsed electric field between
a tool electrode and work roll, which results in tiny, random sharp craters in the surface. In the 3D images, red indicates height and blue indicates depth.

As the 3D images show, the blasted surface exhibits greater variability than the EDT steel surface, though both show pronounced peaks on the material’s surface. These pinpoint peaks are prone to breaking and/or deforming during forming and drawing and can lead to galling, premature tool wear, and die lube contamination. The EDT surface is generally the more consistent type of these two traditional matte finishes.

Grinding wheels or abrasive media can be used to achieve a ground finish to enhance retention of die lube. While this method increases surface roughness, surface properties 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.

When analyzing peak formations on material surfaces, the “skewness” of the surface should be measured to compare 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 and vice versa. Figure 4 shows a profilometer trace of both of these surfaces, as well as a neutral surface with equal peak/valley distribution.

An LBT generated surface inherently exhibits a negative skew, while those produced with traditional finish methods tend to exhibit a positive skew. This difference in surface topography is shown in Fig. 5. Figure 6 shows an enhanced, higher magnification view of the LBT surface, further demonstrating both the lack of pinpoint peaks (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 imparted to materials processed with LBT rolls, the technology achieves a deterministic finish verses the stochastic or “random in nature” surface that is imparted by traditional matte finishes, enabling greater consistency and predictability during forming.
Laser finish details

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

A 2.8-kW CO₂ laser precisely creates microcraters by using a microscopic beam of light energy that is interrupted by an aluminum chopper wheel. Highly precise teeth 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 displaces the molten metal, forming a surface feature similar to a volcanic crater. Uniformity and consistency are achieved by repeating this process 40,000 times per 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 creates a highly uniform, precise 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 improved lubricant-holding capabilities. Benefits of using laser-textured materials 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 process that results in both immediate and long-term benefits.


Structural Adhesives

One and Two Component Epoxies Feature:

- Toughness
- High Tg
- Exceptional bond strength
- UL94V-0 flame retardancy
- Resistance to cyclic fatigue

Hackensack, NJ 07601 USA
+1.201.343.8983
main@masterbond.com

www.masterbond.com