

# The Devil and the Surfaces

by Michel Cardon

**T**he eminent physicist, Wolfgang Pauli<sup>1</sup>, used to say, “God made the bulk; the surface was invented by the devil.” Pauli explained that the diabolical characteristic of surfaces was due to the simple fact that a solid surface shares its border with the external world. Inside the solid, each atom is surrounded by other similar atoms. Surface atoms may interact either with other atoms from the same surface, or with atoms located just below or just above it, or with atoms located beyond it. Therefore, surface properties of a solid are quite different depending upon one’s location. As an example, surface atoms’ minimal energy spatial pattern is often quite different from internal atoms’ minimal energy spatial pattern. Surface structures are complex, and for a long time, every effort made to establish precise experimental and theoretical descriptions of these structures failed.

The surfaces of parts are the location for many phenomena between the material and its environment, where all physical and chemical interactions and exchanges take place. A part’s surface is quite often associated with a useful function—it might be absorbing, reflecting, supporting, insulating, conducting...

Because the processes used to manufacture, treat, protect, coat, or assemble part’s surfaces will determine the service life for the part, surface treatments have a tremendous importance in industry. Yet, partly because of historical reasons, they were, and sometimes still are, underestimated.

## Origin of Sandblasting

Benjamin Chew Tilghman developed the first sandblasting machine. The accounting of how his concept for the process came about may be a myth, but the story is Tilghman, while serving as a General in the Army, observed how sand dust, when blown by wind, could etch window glass surfaces and leave a transparent image of the steel mesh that covered the windows. The story has basis in fact since Tilghman served as a General in the Civil War and was commander of a brigade in Florida.

What is indisputable is that Tilghman is credited with inventing a sand blast apparatus in 1871. He produced the first equipment to replace acid etching used for glass engraving, much “à la mode” at that time for mirrors and for bars, café and hotel windows. Another important use was for engraving tombstones, instead of costly hand-chiselling. This became very popular in a new country where settlers wished to mark their place with a name and brief biography engraved on a tombstone.

Industrial uses came quickly; for instance, the booming market for steel ships required an efficient process to remove

rust and prepare the steel for painting. In H. J. Plaster’s article on Tilghman<sup>2</sup>, he writes about many other applications for Tilghman’s invention as listed in the **National Cyclopaedia of American Biography** including the “removal of scale from forgings and castings; labeling bottles used by chemists and druggists; scouring the outside of bank safes; smoothing armor plates of warships; removing dirt from brick and stone buildings; cleaning tubes, tanks and boilers; refacing wheels of emery and corundum; granulating celluloid films for cameras; perfecting the joints in reservoirs, boilers and tanks; preparing steel rails and girders for welding; exposing cracks in the teeth of milling machines and for taking off the layers of paint successively laid on a ship.”

Many other developments are now familiar to a majority of our readers. However, it is often considered that “shot peening” is the “noble” part of surface treatment, while to others, surface treatment using angular abrasive are of secondary importance. I always try to fight against this pre-cast idea.

A short story to illustrate my point: My company supplied one of the very first CNC blast machine to process ballistic missiles bodies to a precise degree of finish using white alox (aluminum oxide). I later showed this machine to a prospective user at the initial customer site. It was operated by a bright young man. He was playing with the keyboard and push buttons, looking frequently at the CNC CRT display. At my departure, I thanked the workshop manager for the visit and told him, “Seems you have a good machine operator.” The answer was “Shhhh! He can’t read!”

Explanation: The machine operation was understood as “sandblasting”. Because of local union regulations, our customer’s employees couldn’t be offered the job of a “sandblaster”. Therefore, the shop manager picked up his phone, called the staff management department and said, “Hi! Send me a sandblaster!” But the young man was only a temporary jobber: He was bright, quick and memorized controls, etc., but couldn’t read. This magnificent machine, tailor-made to a strict specification, used like this...

In all probability, sandblasting has a lesser reputation from its early days when it was a dangerous profession. Sand is made of silica (Silicon Dioxide, SiO<sub>2</sub>). When used as an abrasive for blasting, it breaks into fine particles. When inhaled, these particles can cause a lethal lung disease, “Silicosis”, also known as the Coal Miners disease. Even with primitive helmets and external ventilation, dust inhalation was inevitable. If you were in a British shipyard in the early 1900s, one could read under the poster: “Join the Navy and see the world”. A chalked warning reads “Become a sandblaster, and see the next”.

So a sandblaster in the early 1900s might have agreed that surfaces were invented by the devil! However, given the complexity of surface physics and the demand today in so many industries for blast cleaning, all surface treatments are deserving of our respect. ●

<sup>1</sup>Wolfgang Pauli. Born in 1900 in Vienna, Pauli was a U.S. and Swiss physicist. Pauli helped to lay the foundations of the quantum theory of fields. He was awarded the Lorentz Medal in 1930 and the Nobel Prize in Physics 1945 for the discovery of the Exclusion Principle, also called the Pauli Principle.

<sup>2</sup>A Tribute to Benjamin Chew Tilghman by H.J. Plaster is available for download at [www.shotpeener.com](http://www.shotpeener.com).



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