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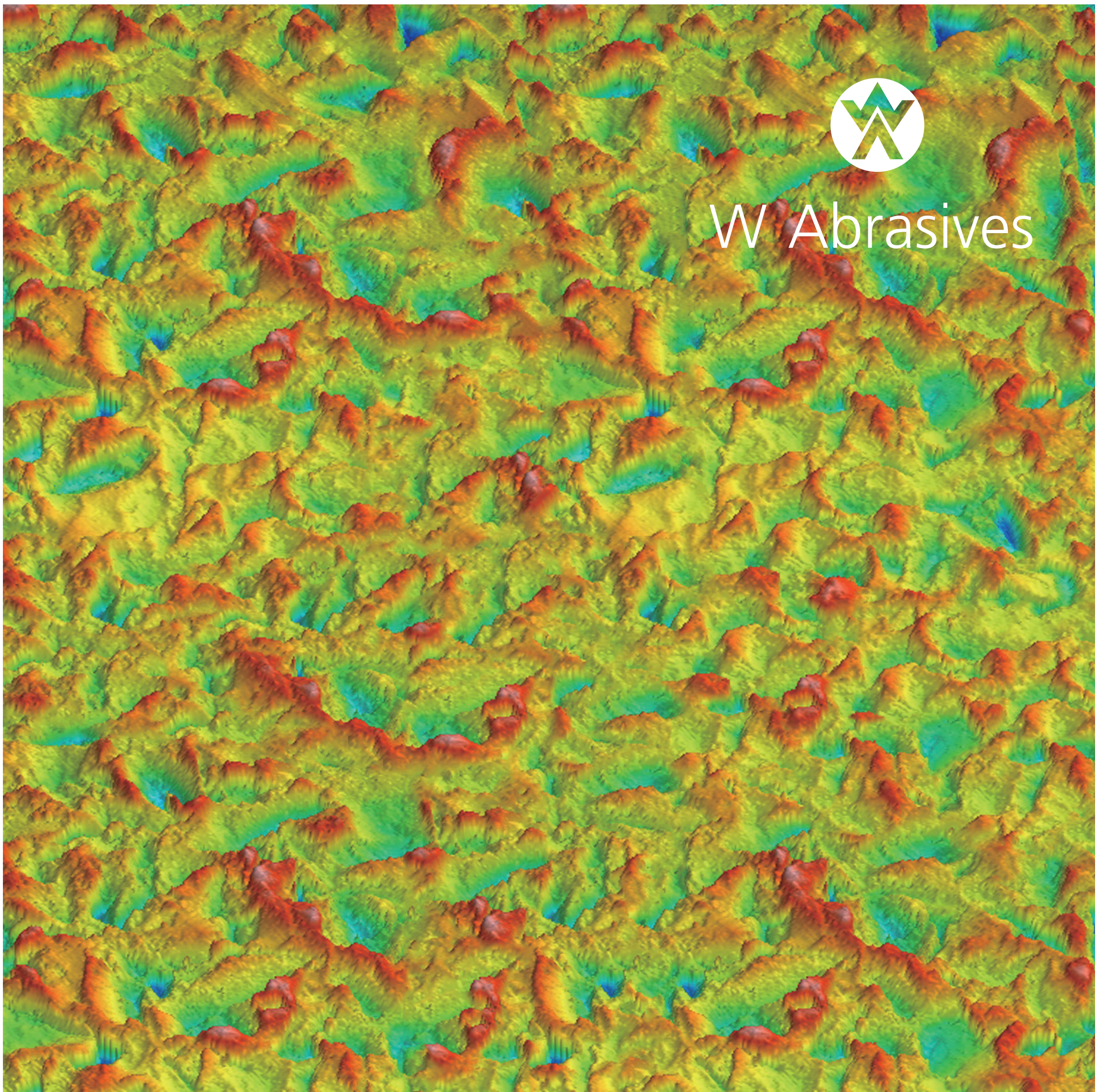
(see page 19)



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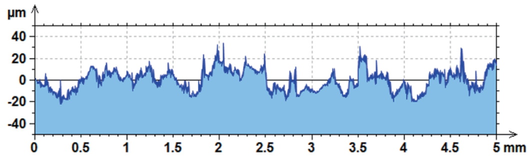
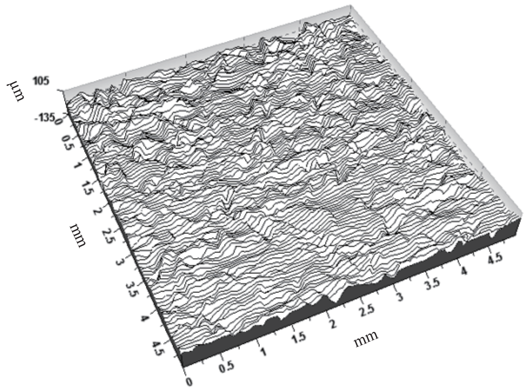
3D Topography for Surface Preparation Applications with 3D Technology



Profile measurement, z=f(x)



Surface measurement, z=f(x,y)

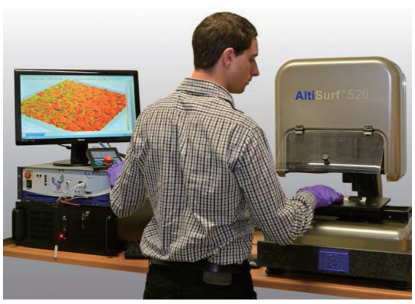
Introduction

In addition to the degree of cleanliness and soluble salts contamination level, surface preparation specifications need to consider the substrate surface roughness. It is well accepted in the surface preparation industry that the roughness parameters play a major role in the interaction between paint consumption and mechanical and corrosion resistance properties of the coatings. Having awareness of the current limitations of the typical bi-dimensional approach (roughness profile measurement using a contact stylus instrument), W Abrasives has developed a new technology called WA 3D. This technology is included within the new surface preparation pack, which contains a full range of solutions (new products, services and tools) in order to bring to customers leading-edge technics and knowledge, allowing the surface preparation industry to progress toward excellence in surface preparation.

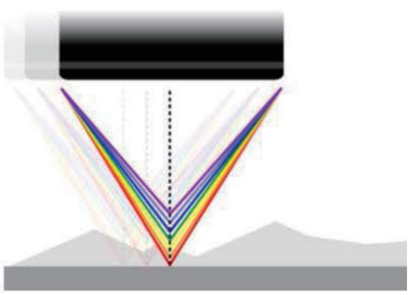
Methods for evaluation of surface roughness after blasting cleaning process

The blast-cleaning process generates isotropic surfaces, in contrast to grinding and polishing that form anisotropic surfaces. Isotropic surfaces are surfaces that have the same topography independent of the measuring direction, while anisotropic surfaces have a clear directionality.
Surface roughness measurement methods include linear roughness measurement, which measures a single line on the sample surface, and areal roughness measurement, which measures an area of the surface. Linear roughness measurement has been the norm until now, but expectations for areal roughness measurement that can see a surface as it really is, have been rising in recent years. There are two major groups of instruments that can supply quantitative and qualitative data for surface topographic evaluations; namely, the mechanical contact profilometers and optical profiling instruments.
The principle of mechanical contact profilometers (contact stylus instruments) is that a pick-up with a stylus is traversed over the surface at a constant velocity. Most mechanical contact profilometers use a diamond tip as a stylus. The tip, attached to a cantilever, is drawn across the surface in the X direction. Vertical movements of the cantilever are registered in an analog or digital signal, and a profile of the surface is recorded. Standard tips for mechanical profilometers are often produced with a radius of 2 or 10 µm and an angle of 60 or 90 degrees. The results obtained describe the altitude in z as a function of the position in x: z= f(x). It is called a 2D scan and one talks of 2D profilometry.
Despite the fact that the typically applied loads for mechanical contact instruments are in the milligram range, if the material is too soft, the surface will be damaged from the load applied on the tip, which is a general drawback for all contact systems. In addition, the mechanical contact profilometers cannot be used for non–destructive evaluations like screw type devices, since the tip cannot evaluate threaded parts.
Optical profiling instruments are non–contact methods, generally faster, and have a better resolution than mechanical contact instruments. The optical profiling instruments use a white light beam as an optical stylus and their operating principle is to measure parallel profiles, with regular spacing, covering a rectangular surface. A height measurement z is obtained as a function of the x position on the profile, and the y position of the profile in the surface. It is called a 3D scan, and one talks of 3D topography.
Winoa Research and Development center is equipped with such an optical profiling instrument AltiSurf 520, produced by Altimet Sas, one of the specialists in 3D surface metrology.
The Altimet 3D scan system consists of:

- AltiSurf 520 unit, comprising motorized x, y, z stages and one confocal chromatic sensor CCS Prima series equipped with a modular optical pen, model CL3MG70. This optical pen is based on a highly innovative confocal chromatic imaging principle. An incident white light pinhole is imaged through a chromatic objective into a continuum of monochromatic images along



Altimet 3D scan system overview



Confocal chromatic imaging principle

the Z-Axis, thus providing a "color coding" along the optical axis. When an object is present in this "colored" field, a unique wavelength is perfectly focused at its surface and then reflected into the optical system. This backscattered beam passes through a filtering pinhole into a spectrograph in order to analyze which wavelength has been perfectly focused on the object, and then accurately determine its position in the measuring field. The confocal chromatic imaging gives access to reliable, accurate and reproducible dimensional measurements with extremely high resolution. The particularity of the CL3MG70 optical pen is the critical indicator that allows measurement of non–reflective materials such as replicating media or solar panels. The spot size diameter is about 8 µm, with a lateral resolution of 4 µm.

- Phenix control unit, the interface between the PC and the machine's hardware.
- External remote control: it allows the moving of the axis and the configuring of a measurement without finding it on the main screen.
- Phenix acquisition software is the Altisurf 520 user interface. It allows the configuring of the parameters and the programming and execution of the measurements.
- Altimap acquisition software is the software used by default for analyzing measurements done by Phenix. Altimap software allows a wide variety of 2D and 3D parameters processing.

Roughness parameters included in the surface preparation applications

2D parameters used for the determination of surface texture (roughness, waviness and primary profile) by profiling methods are regulated by ISO 4287 or ISO 12085, ISO 13565. The last two specifications are dedicated to the automotive industry, while ISO 25178 is the first international standard dealing with areal surface texture, 3D parameters.
The names of 3D parameters start with S for surface or V for volume. They do not reflect filtering conditions and do not have P (primary), R (roughness) or W (waviness) prefixes like the 2D parameters. If a 3D roughness or waviness parameter is needed, the surface must be filtered, using a mathematical operator. By default, 3D parameters are defined on the evaluation area, i.e. the whole surface. While 2D parameters are averaged over a number of sampling lengths, 3D parameters are not.
In the case of 2D parameters, the separation between waviness and roughness is done by filtering. The "cut – off" is the filter which defines the boundary between the roughness and waviness components. The "cut – off" value depends on sampling/evaluation length and the profile type. Generally, for the blast-cleaned surfaces, its value is 2.5 mm. The sampling length is the length on which the surface finish parameters are calculated. On a filtered roughness or waviness profile, the sampling length is equivalent to the length of the cut-off. On a raw profile, the sampling length is equivalent to the total length of the profile called evaluation length. The evaluation length may contain one or several sampling lengths.
Methods of how to evaluate substrate roughness prior to the application of corrosion protective coatings are outlined in ISO 8503. The following contact methods are specified:

- profile comparator (ISO 8503 – 1, ISO 8503 - 2, ISO 8503 - 3)
- stylus instrument (ISO 8503 – 4)

For the blast-cleaned surfaces prepared for further coating applications, the most important profile/surface parameters are:

- height parameters (e.g; Ra - arithmetic mean deviation of the roughness profile, Rz - maximum height of the roughness profile, Rt - the total height of the roughness profile, Rsk - skew, asymmetry of the assessed profile and Rku – kurtosis, sharpness of the assessed profile);
- peak parameters (e.g. Rpc - peak density);
- functional parameters (e.g. Vv - void volume).

The comparator method delivers qualitative results only; it distinguishes between "fine", "medium" and "coarse" profiles. Although the profile comparators were basically developed for steel abrasive, it provides information only related to Rz values.

Steel substrate profile parameters (ISO 8503-1)

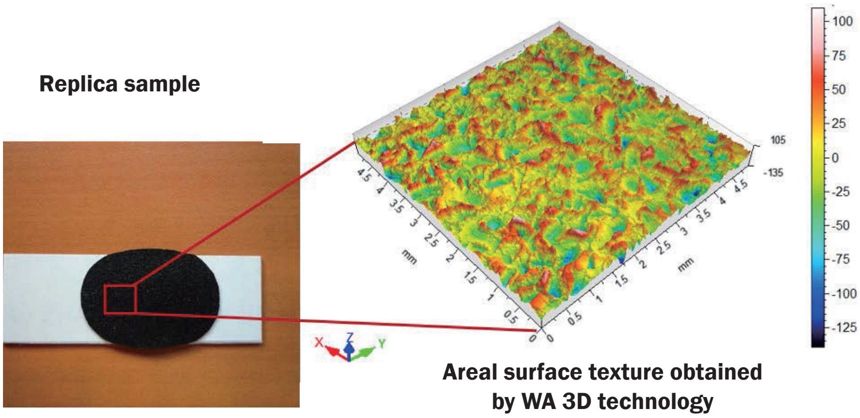
Comparator value	Roughness value, Rz [µm]	
	Grit	Shot
Fine	25 - 60	25-40
Medium	61 - 100	41-70
Coarse	101 - 150	71-100

Usually commercial portable stylus instruments are used to display the following profile parameters: Ra, Rz, Rt and Rpc. Using this method, it is very difficult to reveal the parameters mentioned before on surfaces with a complex geometry.

WA 3D technology by W Abrasives

To be able to provide to customers a full range of 2D profile parameters and 3D areal surface texture parameters after the blasting process, W Abrasives proposes the WA 3D technology. This technology is based on 3D scanning of blasted surfaces replica.
The replica method consists in producing an exact 3D copy of the surface at the customer site in order to be able to measure its 3D topography. To achieve this goal, depending on the surface area to be measured, a hand–operated dispensing gun is used to apply a certain amount of replicating media. The latter one contains both polymer and curing agent that are automatically mixed in a disposable static-mixing nozzle during application to the surface. After a short curing time (about 4 minutes at 25°C), the resin is removed from the surface and the replica sample is obtained, allowing a 3D scan of the surface, whatever the shape, the size or the location of the blasted part.
Using the Altimap software for the results treatment, customized 2D and 3D parameters will be provided in the technical report, depending on customer need (e.g. ISO or ASME standard, cut–off lengths).
Despite the breadth of available 3D parameters, quality professionals continue to specify surface finishes based solely on the 2D parameters. There are several reasons for this tendency: they are well–established and understood; literature and standards are available to explain these parameters; and, perhaps

Replica sample



Areal surface texture obtained by WA 3D technology

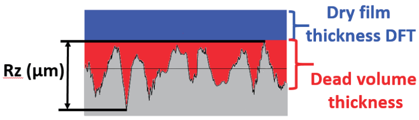
more importantly, historical part data is based on it.
In the case of the surface preparation industry, one of the most relevant examples is the estimation of the paint consumption needed to fill roughness on an abrasive blasted surface, done only by an extrapolation of the Rz values obtained with a portable stylus instrument as follows:

Paint consumption as function of Rz value

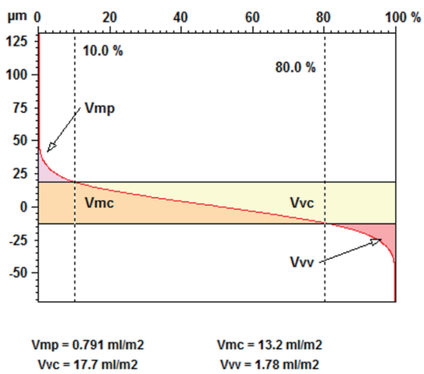
Roughness Rz [µm]	Dead volume [liter/m²]	Dead volume [cm³/m²]
30	0.02	20
45	0.03	30
60	0.04	40
75	0.05	50
90	0.06	60
105	0.07	70

WA 3D technology, apart from classical parameters that are simple extensions of 2D equivalents (such as Sa, Sz, Ssk, Sku), allows the consideration of functional volume parameters, such as Vv – void volume. Functional volume parameters are specific for 3D measurements and they are calculated from the areal bearing ratio curve.
The parameters are defined with the respect of two bearing ratio thresholds, set by default to 10% and 80% according to ISO 25178. Two material volume parameters and two void volume parameters are defined: Vmp – peak material volume, Vmc – core material volume, Vvc – core void volume, Vvv – valley void volume. These parameters are expressed in units of volume per unit of surface (ml/m² or µm³/mm²).

After the blasting process, for a more accurate paint consumption monitoring, the 3D parameter Vv is recommended to be used, for which the sum between the two void volume parameters is mentioned above.
For a specific metallic surface prepared for coating by abrasive blast cleaning, the paint consumption assessment can be totally different depending on the employed method. For instance, in a real case, the classical method (extrapolation from Rz value) gave an estimated dead volume of 0.06 [liter/m²], whereas the functional void volume parameters gave only 0.03 [liter/m²], which is 50% less, for the same abrasive blasted surface!
Since surface topography is three-dimensional in nature, only 3D analyses can accurately represent the natural characteristics of the surface topography. Three-dimensional parameters are more realistic than those obtained from a 2D profile. The statistical analysis of 3D surface topography is more reliable and more representative, since the large volume of data obtained using 3D topography increases the independence of the data. Three-dimensional images can be produced with the help of a computer and a suitable image processing technique. Two-dimensional systems normally use analog measures, while 3D systems mainly use digital techniques. Digital systems are more flexible in processing and storing data. 3D surface metrology concerns other industries like automotive, aerospace, medical, transport, energy. Three-dimensional analysis can provide some functional parameters such as lubrication volume, debris volume, and contact area. Qualitative as well as quantitative evaluation helps to identify sizes, shapes, and volumes of surface features such as pits and troughs, and whether the surface has an orientation.
W Abrasives is always willing to team-up with its customers in order to progress toward excellence, and this new WA 3D approach of the roughness analysis is a relevant way to perform this task. This new technology is included within the new W Abrasives surface preparation pack (Surf Prep pack), which contains a full range of new products, new services (for example on-site conductivity measurement) and new technologies.



Paint consumption as function of Rz value



Paint consumption as function volume parameters calculated on the areal material curve

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