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Spot analysis to determine technical parameters of microblasting cleaning for building materials maintenance

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HIGHLIGHTS

- Analysis of microblasting spot, scarcely studied on building materials.
- Methodology from the standpoint of end-users.
- Evaluation with simple techniques.
- Useful to develop microblasting control protocols on building materials.

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ABSTRACT

This research examines microblasting cleaning spots on different surfaces to analyse technical parameters for building materials maintenance. Spot and surface tests were made keeping parameters constant to evaluate their influence. Analysis of area field roughness obtained through 3D stereomicroscopy, complemented with macrophotography, portable microscope and spectrophotometry analysis were used to surface evaluation. Results indicate the treated area and alteration are related to distance and mainly blasting angle allowing the selection of microblasting parameters when this technique is needed for building materials maintenance. In addition, results point out the necessity of spot analysis before treatment to define the technical parameters to be used in an actual cleaning. Findings concerning microblasting efficiency and effectiveness, including damage to the substrate and other side effects, are also described.

1. Introduction

Microblasting is a mechanical technique used for years to clean building materials. It is mentioned in general publications on building materials maintenance [1,2] and on standards [3–5] or recommendations [6,7] for cleaning buildings.

Microblasting cleaning is based on the application of energy through different abrasives driven by pressurized air to break bonding between surface deposits and substrate by impact, cutting or friction, reducing the use of water or chemical products. Consequently, the correlation between substrate properties (heterogeneity, texture, cohesion and hardness, among others), soiling (mainly thickness and adhesion), abrasives properties and equipment used, will determine the main cleaning mechanism and its effects on the surface.

Depending on these factors, either a precise treatment can be achieved or the substrate can be damaged. Alterations, if any, are related to the predominant impact, cutting or friction mechanism which are reflected as differential erosion, microcracks, loss of shine, etc. [8,9]; i.e. textural modifications favouring later surface alteration.

Reviews and studies about microblasting parameters focussed on industrial applications on metals [10–12]. In this case, removing oxides, burrs or coatings, or preparing materials for standardize surface finishing is intended. These industrial purposes require economic profits generally reflected in process automation.

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Even so, influence of some microblasting parameters in building materials is analysed in different studies [8,9,13–19]. In this case, material, soiling and treatment criteria are different to those related to metals manufacturing.

For both industrial and restoration procedures, the technique is influenced by pressure, distance, angle, time, nozzle, particle-flow and specific abrasive properties (composition, size, specific weight, density, hardness, morphology, friability or toughness, etc.) because it is based on the kinetic energy formula [$Ek = \frac{1}{2}m \times v^2$], where m is mass or abrasive; and v, velocity or pressure. Most of these parameters are not specified in studies or building maintenance projects. Pressure (habitually referred to as low and ranged 1–3 bar depending on the standards or investigations) and abrasive (usually grain size) are all that are mentioned.

Pressure is the most influencing parameter according to kinetic energy formula. The higher the pressure, the faster the particle velocity: the cleaning capacity increases but also the possibility of surface alteration. Some studies in building materials confirm that increasing pressure further weight loss and substrate roughness changes are provoked [13,14].

However, as a cleaning parameter, pressure is not a determining factor if blasting distance and angle are not mentioned because ultimately they modify energy transmitted to the surface.

Blasting distance between nozzle and substrate indirectly modifies pressure regulated on equipment manometer as well as treatment spot size. Increasing distance, particle energy diminishes due to air friction and spot area enlarges because the abrasive jet widens, or vice versa. Distances ranged 2–10 cm using microblaster or suction gun equipment and 10–50 cm for large equipment are mentioned in some studies on cleaning building materials [14–18].

Blasting angle modifies spot morphology. Using right angle spot morphology is circular; using acute angles, elliptical. Furthermore, using acute angles in comparison with right angle, pressure regulated on equipment manometer indirectly diminishes because actual distance between nozzle and substrate slightly increase (and consequently particle energy slightly decrease). Blasting angle also modifies the main cleaning mechanism. Particles clean by impact using right angle while friction or cutting mechanism prevail using acute angles (making milder the treatment a priori).

Blasting angle is not usually referred in studies on building materials although it is mentioned on some roughness tests [8], in research papers and in specific case studies [17,18]. It is usually proposed 45° angle as safer than 90°, even though recent studies on siliceous sandstones and on lime and gypsum render coatings [20–22] have point out that the least aggressive is close to 75°.

To understand the influence of these parameters in an actual cleaning it is necessary to recognize how the operator (or restorer, depending on the building historical significance) performs microblasting. In this technique, he manually moves a nozzle driving pressurised air and abrasive that generates a spot on the surface. The continuous impacts of particles removing soiling, together with its visual observation, determine when the required cleanliness has been reached.

As an actual microblasting depends on the operator's manually operated nozzle movement and on spot overlapping on the surface with the selected parameters, it seems necessary to study the spot as a starting point. References to spot analysis are not usual [8]. However, it is important to know how particles are distributed in a particular area. Analysing spot characteristics could allow to set up previous tests before cleaning and to propose potential modifications during treatment according to the requirements.

From these assumptions, the aim of the study is to evaluate some poorly documented aspects of microblasting on building materials, mainly blasting angle and distance. Besides, it attempts to point out the necessity of spot analysis to characterize and define this treatment, as in other cleaning techniques [23], searching for its representativeness in common situations, presenting data easily interpretable by the operator and highlighting potential surface alterations.

2. Materials and methods

Two different tests were made: spot tests (on an industrial cardboard and on a commercial marble plate) and surface tests (on the marble plate).

Before carrying out trials on building material, specific parameters of microblasting spot on cardboard were studied. The purpose was to analyse spot characteristics through a modelling on a relatively homogeneous, soft and smooth substrate in comparison to building materials. Cardboard was selected because changes in its surface would be easily perceptible.

Afterwards, spot tests were made on marble plate focusing on effects due to microblasting angle and distance on its granoblastic texture. Subsequently, surface tests were made on the same marble plate to compare and ascertain if parameters referred to in industrial applications and results obtained after spots analysis could be extrapolated to building materials.

Cardboard (300 × 150 × 2.25 mm) was manufactured by applying to three layers of different composition. On the obverse, a 0.05 mm thick green offset print on a 0.3 mm thick white paper —conifers mechanical pulp (85%) and conifers bleached chemical pulp (15%)—; in the core, a 1.5 mm thick brown corrugated cardboard —hardwood semi-chemical pulp (80%), conifers and deciduous bleached chemical pulp (15%) and softwood chemical sulphate pulp (5%)— and underneath, a 0.4 mm thick white paper —softwood chemical sulphate pulp (50%), conifers bleached chemical pulp (20%), conifers mechanical pulp (10%), hardwood semi-chemical pulp (10%), and hardwood bleached chemical pulp (10%)— (Fig. 1). For evaluation, the green offset print was considered as a thin and adhered soiling layer, and the remaining strata, the substrate.

Building material was a polished Macael marble plate (350 × 150 × 20 mm) deliberately soiled with acrylic black paint in spray. Macael is a white-light grey calcitic marble with granoblastic texture and grain size ranging 0.16–3.2 mm, predominating 1.5 mm. It is almost a monomineral marble composed of calcite, small amounts of quartz and isolated muscovite and feldspar crystals (Fig. 1). It has a reduced porosity, low mineral hardness and moderated abrasion resistance [24–27]. It is extracted from nearby Macael and El Chive towns, both located in the south-eastern of Almeria (Spain).

It was selected due to its common use as ornamental stone and because alterations provoked by microblasting would be easily identifiable (brittle, soft, homogeneous and smooth surface with compact, adhered and uniform in thickness surface deposit). Its mineral medium hardness and the difference in grain size and crystals orientation are the most likely properties influencing potential damage by microblasting. Its low porosity, its polished finishing and the thin paint layer seems to facilitate cleaning process.

Simple techniques were used to distinguish the main materials properties. Cardboard was analysed by staining techniques under optical microscope (Motic B1) and SEM-EDS (Zeiss EVO®MA 10) and marble thin section by petrographic microscope (Optika N400POL).

Several techniques were used to evaluate cleaning tests. Spots on cardboard and marble were analysed by macrophotography and USB digital microscope to identify morphological changes (considered as in situ evaluation). Besides, marble spot images were adjusted to maximum levels of brightness and contrast