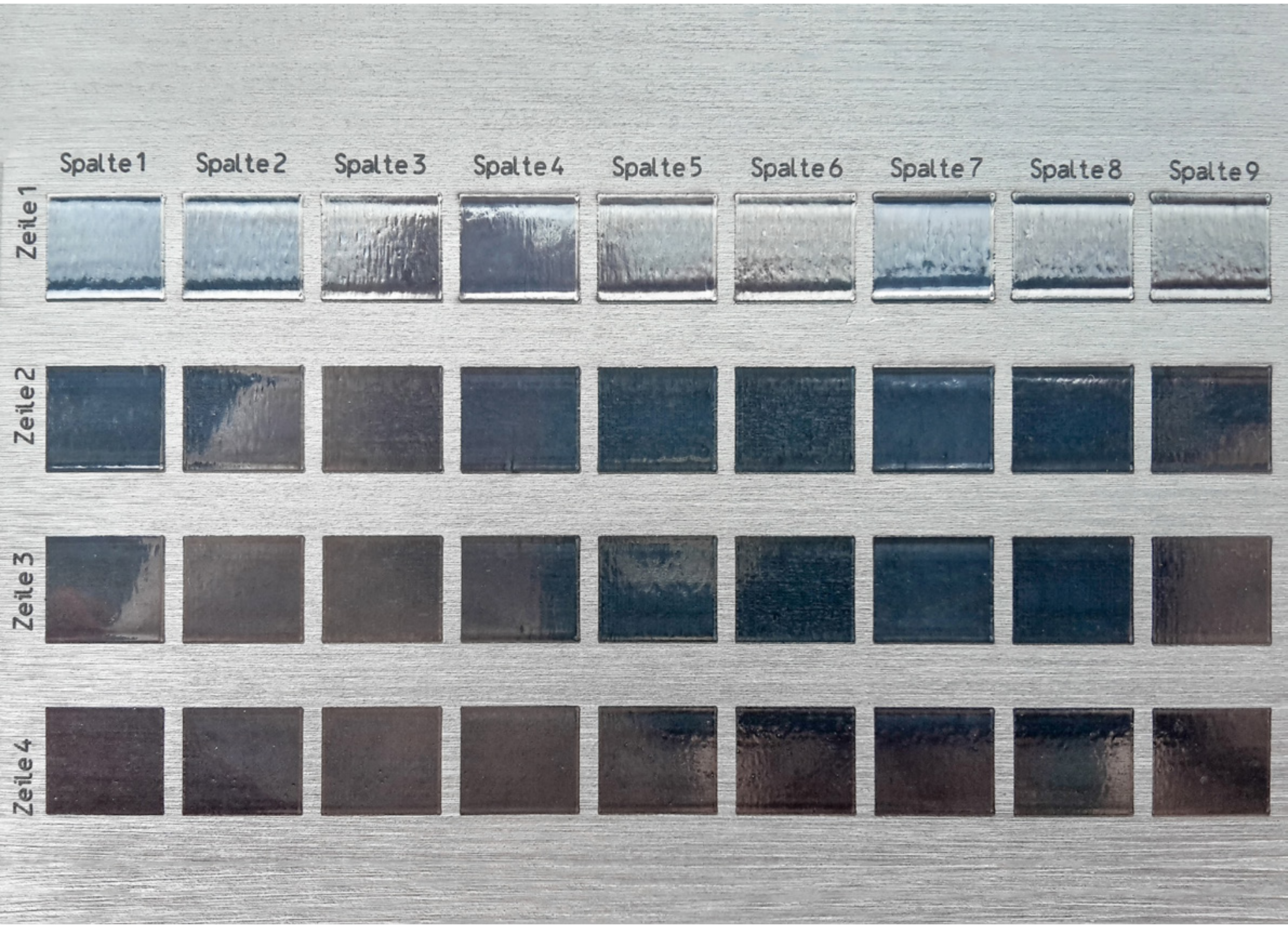

ZEISS Smartzoom 5

Analysis of Defects in a Laser-polished Surface

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Analysis of Defects in a Laser-polished Surface

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Date: March 2017

During the development of a laser-polishing process, defects in the matrix of polished squares are detected on the surface of aluminum die-cast parts using high-resolution microscopy. ZEISS Smartzoom 5 can automatically and rapidly analyze a multitude of samples.

Introduction

Compared to the conventional method of subtractive mechanical polishing, the extremely young technology of smoothing the surface of metallic parts by remelting the near-surface layer using laser radiation represents an innovative method. As a result, it is possible to work in a contactless manner, without the use of force, and with the benefit of preserving the volume of the part. When polishing martensitic stainless steel, the ability to simultaneously harden the surface layer during polishing also exists. Typical areas of application include functional surfaces, such as friction or sealing surfaces, that demand a higher level of surface quality. Automated polishing technology has the considerable benefit of saving time and cutting costs, for example when it comes to finishing parts with complex shapes in tool and mold manufacturing, which with today's common and conventional methods need to be manually polished in a time-consuming and cost-intensive process.

To prevent the formation of oxide layers during the process, it is carried out inside a processing chamber in an inert gas atmosphere (Fig. 1).

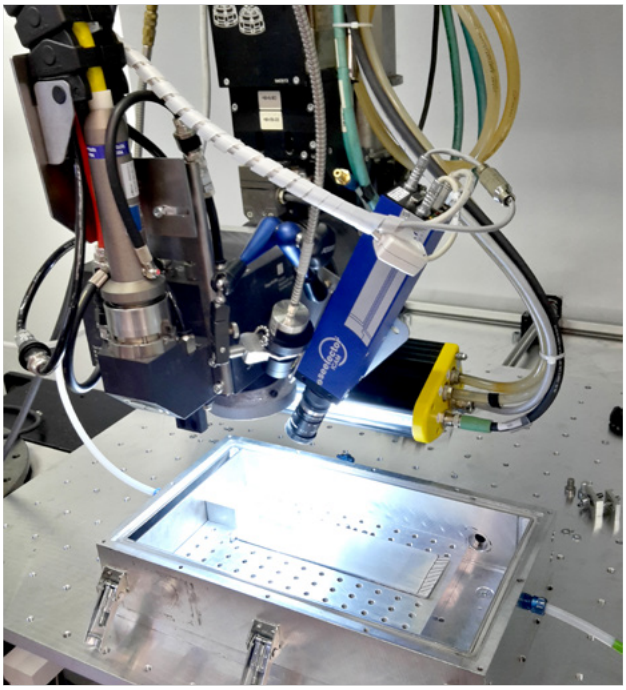

Figure 1 *Laser processing cell with polishing assembly at Aalen University.*

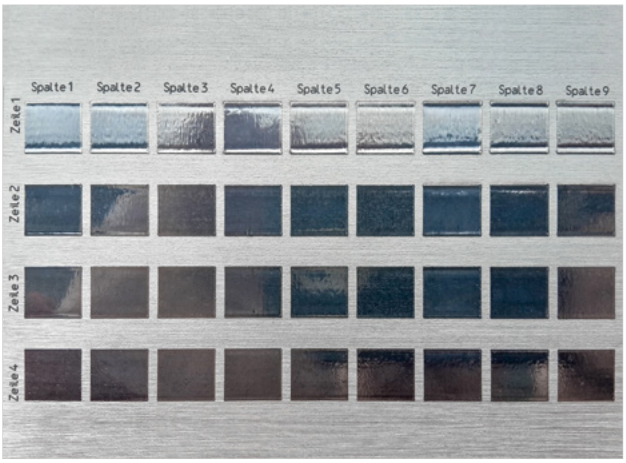

Figure 2 *Aluminum sample with matrix of polished squares.*

Figure 3 *Smartzoom 5 with laser-polished sample.*

Depending on the composition of the part and its original surface, parameter studies need to be carried out while varying the beam source process parameters, such as beam intensity and pulse duration, as well as the beam guidance process parameters, such as feed rate and overlap. To this end, polished squares measuring 10 mm × 10 mm are attached to the samples at an equal distance from one another, forming a parameter matrix (Fig. 2).

In addition to quantitative surface characterization using surface properties (such as Ra, Rz, and Rt), the goal is to detect surface defects and categorize them by location, size, and frequency. In order to detect surface defects (such as pores, ripples, penetrations, and deposits) caused by the contamination of the original surface or oxide islands, all of the polished squares need to imaged with a microscope.

Creating the imaging job

ZEISS Smartzoom 5's "Routine Analysis" feature allows you to create a job that can be routinely used to automatically capture microscopic images of a matrix of polished squares with up to nine columns and four rows. As a result, this dramatically reduces the amount of time the user needs to capture the images.

Figure 3 shows the measuring job with ZEISS Smartzoom 5. The laser-polished sample is aligned and positioned in a repeatable manner using the stops on the X-Y stage.

Before beginning a new job, an overview image is first captured (Fig. 4).

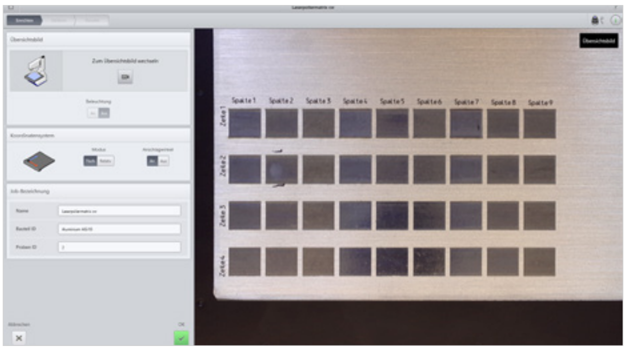

Figure 4 *Creating an overview image.*

The intuitive user interface allows the user to automatically find a suitable illumination setting with the help of the "Best Image" feature. In this context, the respective illumination modes can be selected from coaxial brightfield illumination and ring light (Fig. 5).

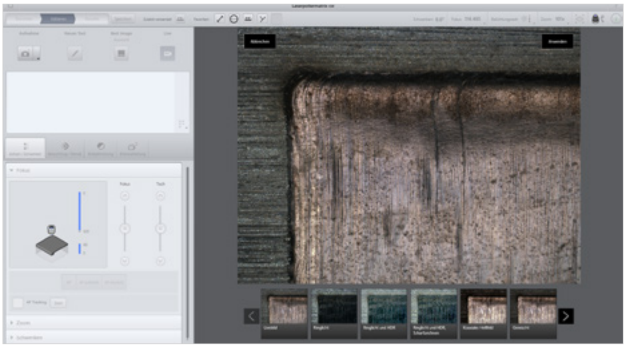

Figure 5 *The "Best Image" feature for intuitively adjusting illumination settings.*

The polished surface offers the highest contrast when using a mixture of ring light in combination with coaxial bright field illumination (Fig. 6).

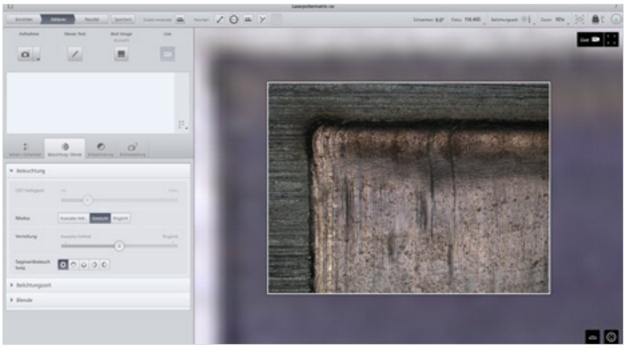

Figure 6 *Optimized illumination settings for polished surfaces.*

To ensure that the individual polished squares are imaged with sufficient resolution to identify defects, the images are captured at 100× magnification. This provides a pixel accuracy of 2.5 µm × 2.5 µm. For an area one square centimeter in size, this requires a square stitching matrix of 4 × 5 individual images (Fig. 7). To ensure that the microscopic images have sufficient depth of field, the "Extended Depth of Field" feature is superimposed over the stitching mode.

Figure 8 shows the complete combined image of a polished square with edges measuring 10 mm × 10 mm.

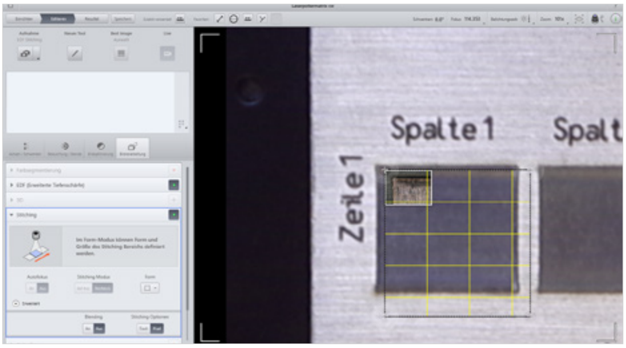

Figure 7 *Stitching settings for an entire polished square.*

Using the "Routine Analysis" feature, the user only needs to carry out the entire job capturing a matrix of polished squares once. The device saves all of the settings and imaging positions in the background during initial setup. Afterwards, the process can be carried out extremely efficiently in a semiautomatic process for as many samples as desired, as long as the sample matrix remains identical. The user can adapt to changes in the material thickness of the polished metal samples during routine processing by manually readjusting the focus position.

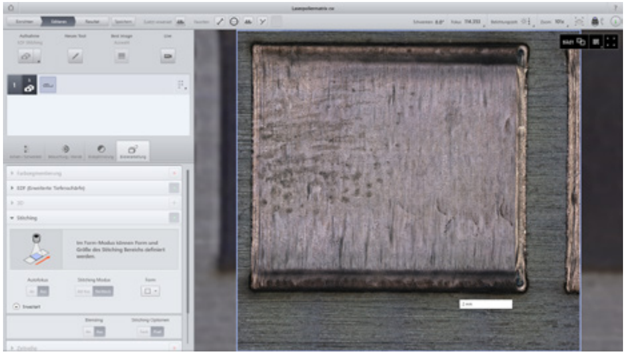

Figure 8 *Image of a polished square with a 4 × 5 stitching matrix.*

All of a job's individual images are saved for subsequent image analysis with ZEISS ZEN 2 core as individual files in CZI format.

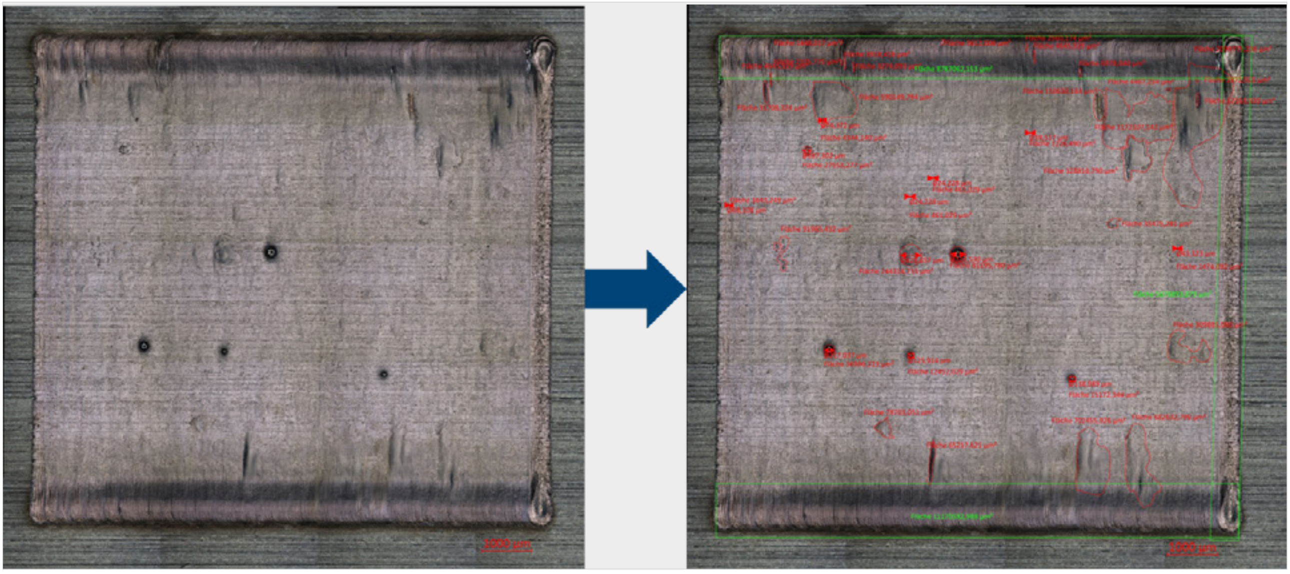

Figure 9 *Defect measurement and characterization with ZEISS ZEN 2 core (left: raw image, right: geometric measurement).*

Analyzing polished surfaces for surface defects

The actual defect analysis is carried out offline on office workstations using ZEISS ZEN 2 core software. Figure 9 shows the raw image of a polished square on the left. Surface defects, such as pores, collections of material, oxide deposits, or other deposits, are measured geometrically and labeled (Fig. 9, right).

Within the scope of the research project entitled "Developing a Complete System for Laser Polishing Aluminum Pressure Die-Cast Parts with Online Camera Analysis and Control," which is being funded through the German Federal Ministry for Economic Affairs and Energy's ZIM research program, the camera-based defect detection algorithm is being developed in cooperation with the companies hema electronic and Scholz Metallschleiferei with the help of this microscopic analysis.

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