Lasers in Manufacturing Conference 2015

Reconditioning of lamellar graphite cast iron parts by means of laser cladding and heuristic-based process parameter adaption

M. Möller*, C. Emmelmann

iLas Institute of Laser and System Technologies, Hamburg University of Technology (TUHH), Denickestrasse 17, 21073 Hamburg, Germany

Abstract

Clad layer based on a two-stage experimental study of laser cladding on grey cast iron, a heuristic approach for the prediction of the process parameters is presented. Different repairing strategies using two Ni-based alloy powders are analyzed in an experimental design. Along this results the correlation of dilution, aspect ratio and the weld seam quality is investigated. The mathematical description of cladding quality under the condition of different dilutions and aspect ratios is used to define the repair requirement. The aim is the identification of the process parameters necessary to produce a good quality weld. Since the clad layer quality depends on various influence factors the direct way of determining the suitable parameters is not a possible solution in many repair applications because of the complex free-form geometries of the damaged areas, the various material conditions, differing part thicknesses and many more. The influence of the differing part thickness and along with this the different thermal situations in the part are chosen exemplary to show the capability of process parameter prediction by the usage of neural networks.

Keywords: laser cladding, reconditioning, lamellar graphite cast iron, inverse modelling of process parameters

1. Introduction and motivation

Apart from the production of local part reinforcements, the addition of wear resistances and plating, one of the main applications is the reconditioning of cost-intensive components (material price, manufacturing costs, etc.). Maintenance in the field of marine diesels or for mechanical and plant engineering industries often

* Corresponding author. Tel.: +49 - 40- 484 010 621; fax: +49-40-484 010 999.
E-mail address: mauritz.moeller@lzn-hamburg.de.

affect cost-intensive, large-volume parts. The occurring damages may have already resulted from the manufacturing or from the operating process. For a lot of applications successful reconditioning processes were developed and put into practice. However, these processes are currently limited to materials with a sufficient reserve of plastic deformability. Despite of the high market share (e.g. gray cast iron approx. 50% of cast iron materials), for cast materials with a low fracture strain (e.g. lamellar graphite cast iron) there does not exist a suitable reconditioning process at present (Wagner 2011).

Laser-Cladding is characterized by the reduced thermal stresses of the regarding part during the reconditioning as well as the high accuracy of the material coating. Thus the coated layers can be manufactured “near net shape”, meaning close to the final geometry of the part. This leads to a minimized post-treatment effort. During the reconditioning the component’s damaged areas are prepared (cleaning, milling, etc.) and subsequently, depending on the application, coated with dissimilar materials. Thereby the local mechanical properties can be exactly adapted to the requirements and in comparison to the original part an improved version can be provided (Emmelmann 2010).

In this presentation, an innovative approach based on neural networks (Bishop 1995) shall be introduced, describing how brittle materials can be treated with the Laser-Cladding process by defining adapted dynamic process windows. Using a simulation-based adaptive prediction of the Laser-Cladding process parameters an optimized heat input can be realized. Hence by applying this dynamic process window approach the different challenges in the reconditioning process for locally varying properties of the parts can be taken into account - like the brittle material behavior, varying structure and mechanical properties caused by the casting process, geometrical dimensions and different damage shapes.

2. Methods and heuristic model development

The identification of the complex relation between the process parameters as well as the boundary conditions and a desired high quality clad layer lead to a huge experimental effort. So in the case of repair applications there are varying conditions for every part resulting from different defect situations. In order to produce a higher effectiveness of the refurbish process on the one hand it is necessary to decrease the experimental effort and on the other hand *increase* the quality of the clad layer.

2.1. Laser cladding and materials

Laser powder cladding is widely used in several repair applications because of its low heat input into the part resulting in low distortions and low effect on material constitution. In this work the experimental setup is based on a disc laser TruDisk6001 in combination with a SO16 processing head with three powder nozzles and a powder feeder Trumpf deposition line.

In figure 1a the setup used for the experiments presented in this work is shown. The specimen consist of the base material EN-GJL-250 and are all machined to a geometry that three single clad layers can be applied to (figure 1b). As the powder material on the one side a Ni-Cr- based alloy and on the other side nearly *pure* Ni alloy is used for the cladding with particle sizes between 50 and 150 µm. In all cases spherical shaped powder material is used to ensure a constant powder feed. The composition of the powder material is shown in table 1.