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Statistical knowledge for industrial competitive advantage in laser drilling process

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The activities were developed in collaboration with Aerospace Engineering Department of University of Naples "Federico II"

Introduction

The case study involving laser drilling process has been developed in AVIO industry, an aerospace company at the leading edge of propulsion technology.

This work shows the strategic role that a systematic approach to planning for a designed industrial experiment plays in technological process innovation.

Problem Definition: Drilling of the afterburner of EJ200 engine, called Heat Shield, partially coated by an internal thermal barrier (TBC).

The holes on the area without thermal barrier were mainly made by DOF (drilling on-the-fly) method; the holes on coated area were made by trepanning because of unsatisfactory quality of the holes achievable by DOF method.

Objective: To extend the use of the DOF method to this area in order to increase productivity and keep meeting geometrical and metallurgical requirements.

Since the results obtained spring from a sound systematic approach, they enable to plan a future experimental phase on optimization and robustness.

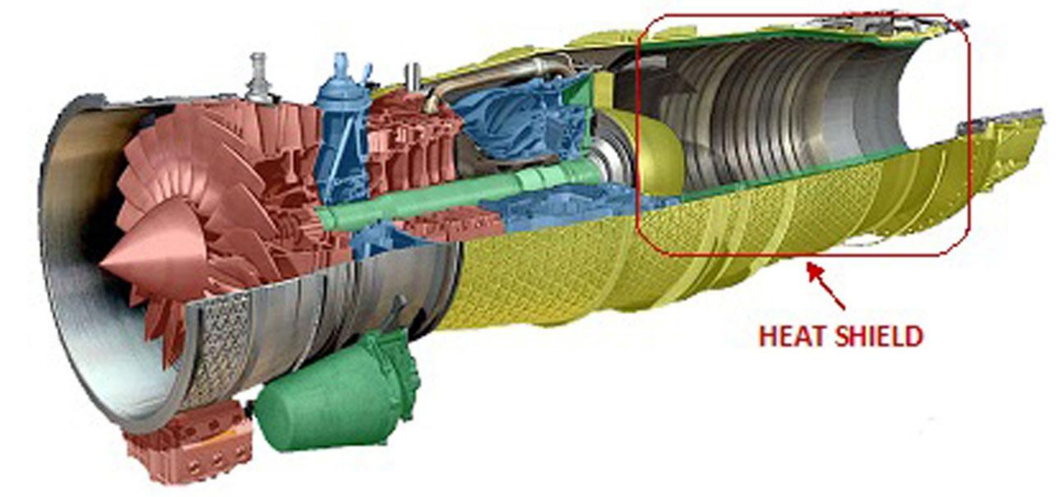

Fig.6 Cross section of EJ200 engine

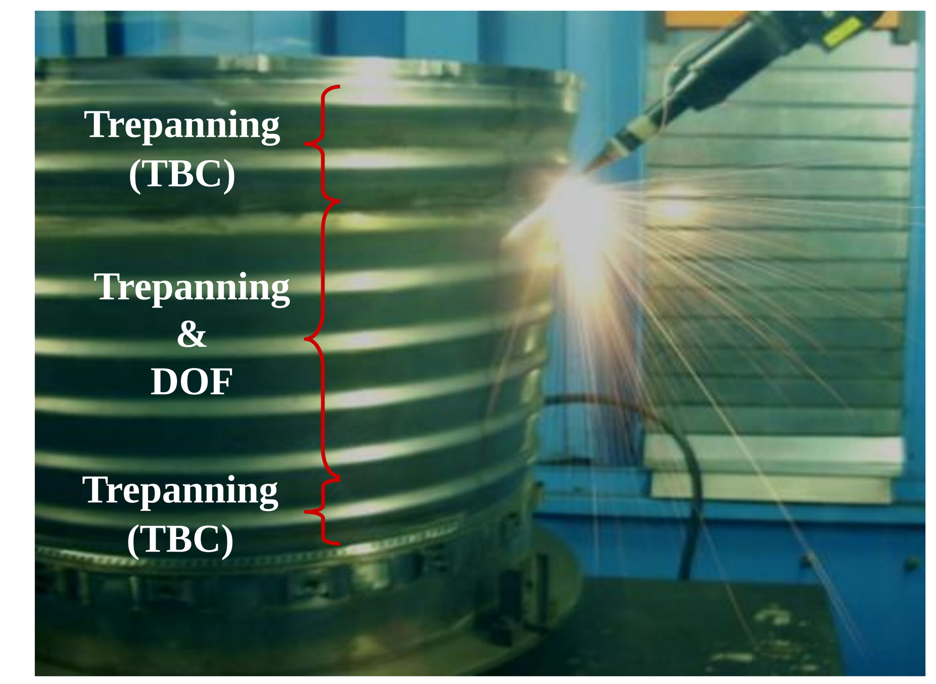

Fig.7 Laser drilling of Heat Shield

Screening

Five factors are held as important and a 2^{5-1} design is adopted to obtain reliable information about main effects and two-factor interactions.

- 3 replications
- 48 experimental runs
- Response variables: taper and recast layer thickness

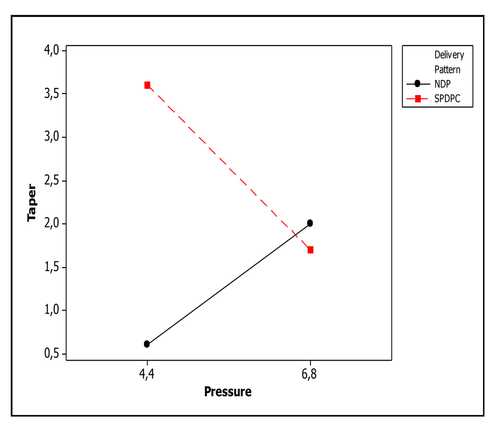

Fig.1 Anti-synergic two-factor interaction for taper

Results:

➢The anti-synergic two-factor interactions for the response variables were the true "discoveries".

➢It was showed the advantage of using the high pressure and SPDPC (a particular temporal laser pulses train modulation) both never applied in Avio.

➢The team approach has been the real driving force of pre-experimental activities; it enables to integrate engineering and statistical knowledge and catalyze the process innovation and, moreover, it allows to put into action a virtuous cycle of sequential learning.

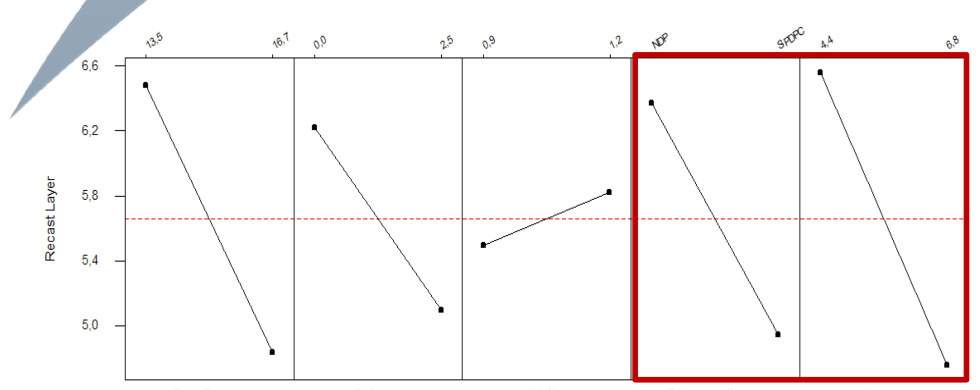

Fig.2 Main effects plot for recast layer thickness

Optimization

A Face Centered Central Composite Design (CCD) was used for fitting second order response surface regression model. The Response Surface Methodology (RSM) allowed to optimize both the response variables.

- CCD face centered (α =1)
- 2 replications
- 3 center point replications
- 68 experimental runs
- Response variables: taper and recast layer thickness

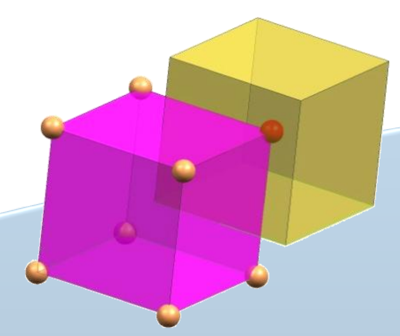

Fig.3 Experimental domains, pink for screening, yellow for optimization, red dot for screening optimum

Results:

➢SPDPC was confirmed as the best approach to laser drilling.

➢An optimal laser parameter setting was found (optimal point of response surface). This setting was subsequently tested and qualified.

➢Industrialization Phase: the DOF method was extended to the coated area in production context.

➢Saving: 20% reduction in manufacturing time.

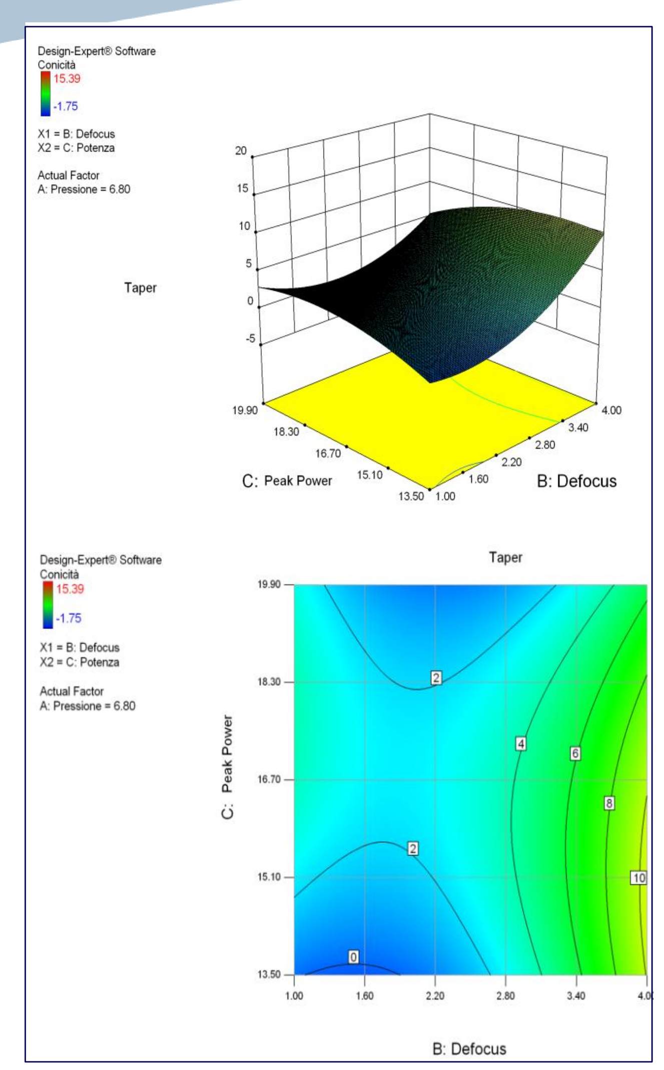

Fig.4 Response surface and contour plot for taper

Awards & Funding

Awards

The optimization experimental phase has won the "Giuseppe Massaro National Prize (2009), for working on applicative laser solutions in industry".

Funding

Project: Study and implementation of high-brilliance and energy saving laser source for micro-drilling machining of aerospace components. (Funding: Italian Ministry of Economic Development, PON - 46/82 F.I.T. - in evaluation).

The aim of the project is to achieve productivity increasing and cost reduction to perform micro-holes for spray bar and liner. This target will be obtained by the implementation of an innovative drilling process based on high-brilliance laser source (Fiber Laser) instead of Electron Discharge Machining (EDM).

Robust Design: One of research project objectives is process robust design. This methodology allows to find the best combination of control factors that optimizes laser drilling process parameters and minimizes the noise factor effects.

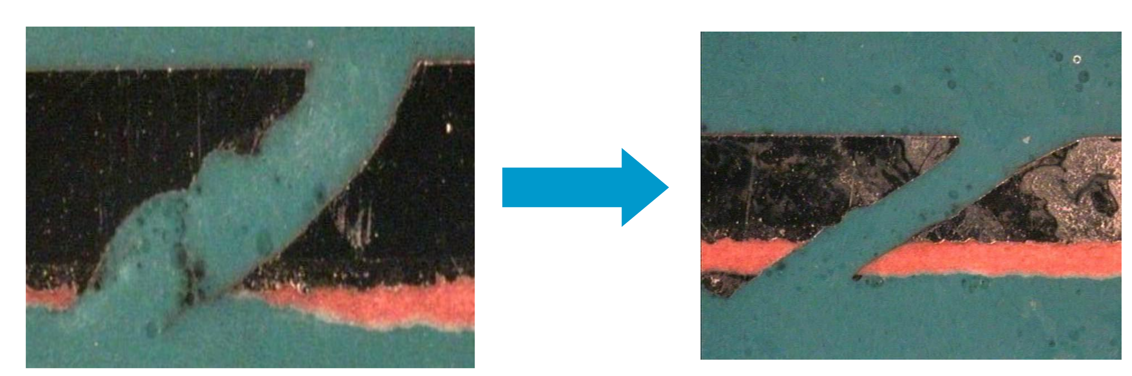

Fig.5 A hole drilled by DOF method before the screening (left) and after the optimization phase (right)

Competitive Advantage

Statistical Awareness

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