19th INTERNATIONAL CONFERENCE ON EXPERIMENTAL MECHANICS

ICEM • 2022
17-21.07.2022 Kraków
POLAND

BOOK OF ABSTRACTS

KRAKÓW, POLAND

17-21 July, 2022

Edited by:
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www.icem19.org

INSTITUTE OF FUNDAMENTAL TECHNOLOGICAL RESEARCH
POLISH ACADEMY OF SCIENCES

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WARSZAWA-KRAKÓW
2022

ISBN 978-83-65550-38-5

Published by
Institute of Fundamental Technological Research
of the Polish Academy of Sciences (IPPT PAN)
5B Pawińskiego St., 02-106 Warszawa, Poland

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Type setting and cover: Dariusz Rudnik

CURVATURE CHANGE IN LASER-ASSISTED BENDING OF INCONEL 718

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1. Introduction

With a growing interest in application of high-strength and difficult-to-form materials, the processes of forming aided by local heating of the workpiece are under development in recent years. Laser-assistance has been successfully incorporated into numerous forming technologies, like bending, spinning, single point incremental forming (SPIF), roll profiling, stamping, deep drawing, stretch forming, hydroforming or wire drawing [1]. The aim of this study is an attempt to quantify the contribution of laser heating in the laser-assisted bending process.

2. Experiments

Thermo-mechanical bending experiments were conducted with specimens made of the annealed Inconel 718 nickel-based superalloy. Experimental setup is shown in Fig. 1. Each specimen (1) with the cross-section 20 x 1 mm was clamped in the cantilever arrangement. The initial pre-stress condition was realized with a holder of weights (3), which was attached at a distance 175 mm from the clamped end. In a series of five experiments the weights produced external mechanical load Q1 to Q5 of the values: 1.1, 1.57, 2.03, 2.98 and 3.91 N. Specimens loaded in the elastic range were next heated by a CO_2 laser beam (2) of CW power 500 W and laser spot 20 x 2 mm, which was moving with velocity v = 3.33 mm/s towards the clamped end. Each specimen was coated with a black paint in order to increase the absorption of the laser energy. The deflection (Fig. 2) of the specimen due to mechanical loading and laser heating was measured with the optical displacement sensor (5) and an auxiliary plate (4). Details of the experimental procedure are described in [2].

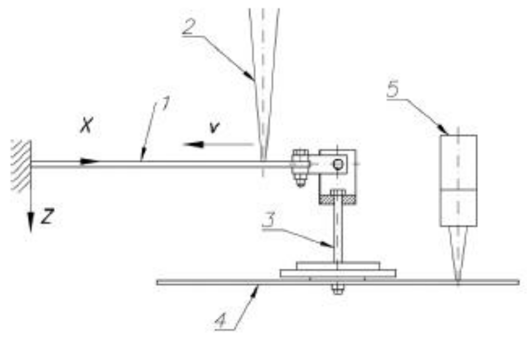

Fig. 1. Experimental setup (1 – specimen, 2 – laser beam, 3 – holder of weights, 4 – auxiliary plate, 5 – optical displacement sensor)

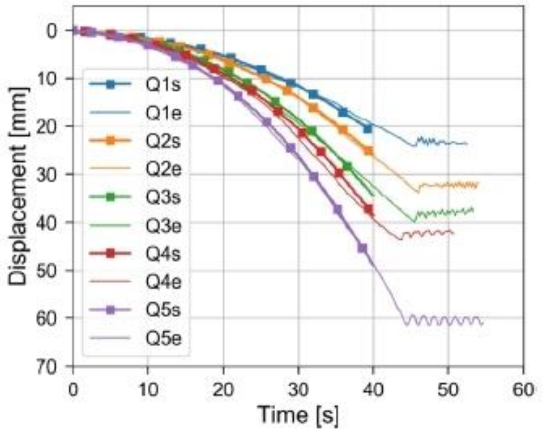

Fig. 2. A comparison of the deflection in: experiments (e) and numerical simulations (s)

3. Numerical analysis

A numerical FE model of the thermo-mechanical bending process was developed in order to: (1) validate the process modeling with the Johnson-Cook constitutive material model and (2) numerically determine the curvature (Fig. 3) of specimens in the XZ plane after mechanical loading (Q), laser heating (L) and final unloading (F). Detailed description of the material and processing modeling is presented in [2]. The curvature C was calculated using the parametric representation $x(s)$, $z(s)$ of the specimen configuration to account for the cases of large deflections:

$$C = \frac{|z''x' - x''z'|}{(x'^2 + z'^2)^{3/2}} \tag{1}$$

where ()' and ()" denote the first and second derivative with respect to the parameter s, respectively.

4. Results and conclusions

The obtained dependence of specimen curvature on the bending moment is shown in Fig. 3. The red dot in Fig. 3 depicts curvature for the case of pure laser bending, i.e. without any external mechanical loading. The effect of "noise" seen in Fig. 3 can be attributed to the numerical differentiation procedure applied in calculating the curvature.

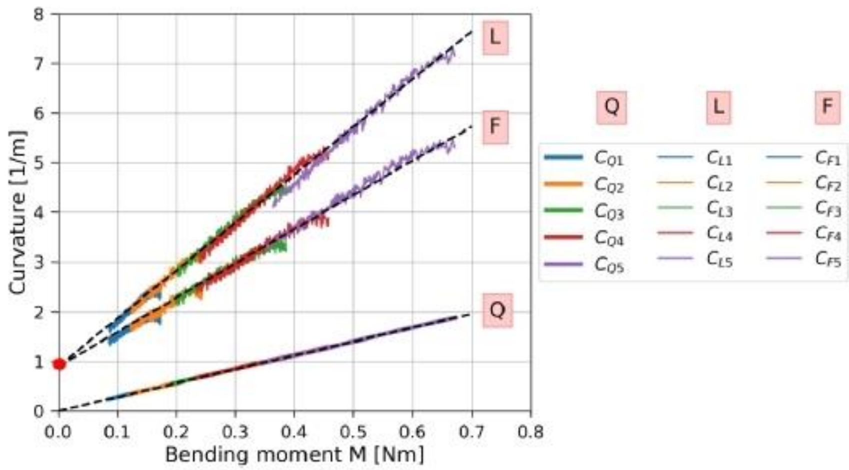

Fig. 3. Curvature dependence on the bending moment with loads Q1 to Q5, as calculated after: initial mechanical loading (Q), heating with a moving laser beam (L), final unloading (F)

The results presented in Fig. 3 suggest that the curvature after laser-induced thermo-mechanical bending process can be estimated as a linear function of the initial mechanically-induced curvature with the free term equal to the value of curvature resulting from the pure laser bending process.

5. Acknowledgements

The research reported herein was supported by a grant from the National Centre for Research and Development (No. PBS3/A5/47/2015).

6. References

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