Production and optimization of 316L stainless steel dimples by laser surface texturing using Nd: YAG laser

Ângela Cunha, Ana Rita Ferreira, Ana Cristina Marques, Bruno Trindade, Filipe Silva, Óscar Carvalho

Universidade do Minho

XIX Brazil MRS Meeting August 30th to September 03rd IUMRS ICEM 2021 VIRTUAL

31st August 2021

UMINHO CMEMS CENTER FOR MICROELECTROMECHANICAL SYSTEMS

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1. Motivation

MATERIAL

Austenitic stainless steel

316L stainless steel

1. Motivation

MATERIAL

Austenitic stainless steel

316L stainless steel

- Resistance to corrosion
- Resistance to oxidation
- Machinability

1. Motivation

MATERIAL

Austenitic stainless steel

316L stainless steel

- Resistance to corrosion
- Resistance to oxidation
- Machinability

BUT…

- Mechanical strength
- Tribological properties

1. Motivation

MATERIAL

Austenitic stainless steel

316L stainless steel

- Resistance to corrosion
- Resistance to oxidation
- Machinability

BUT…

- Mechanical strength
- Tribological properties

Surface modification and/or Addition of MMC's

1. Motivation

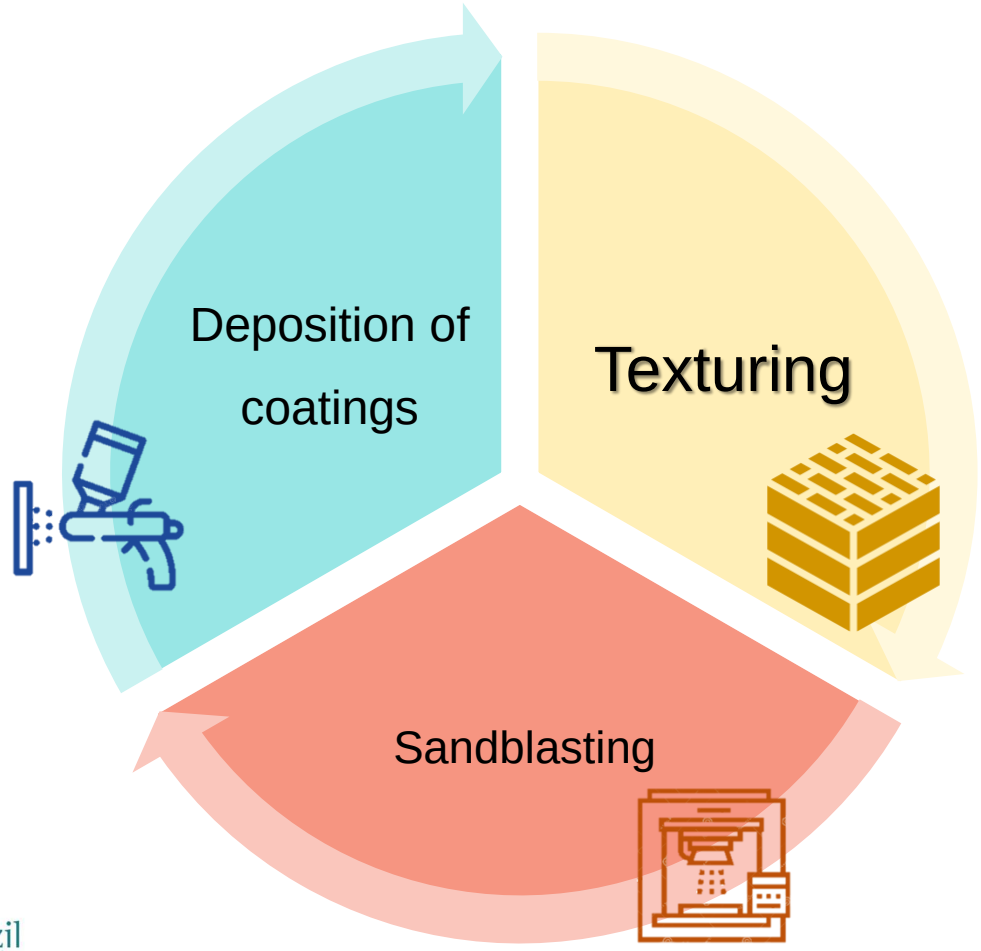
SURFACE ENGINEERING

> *Improve the lifetime of metallic parts and tools*

Researchers and industries

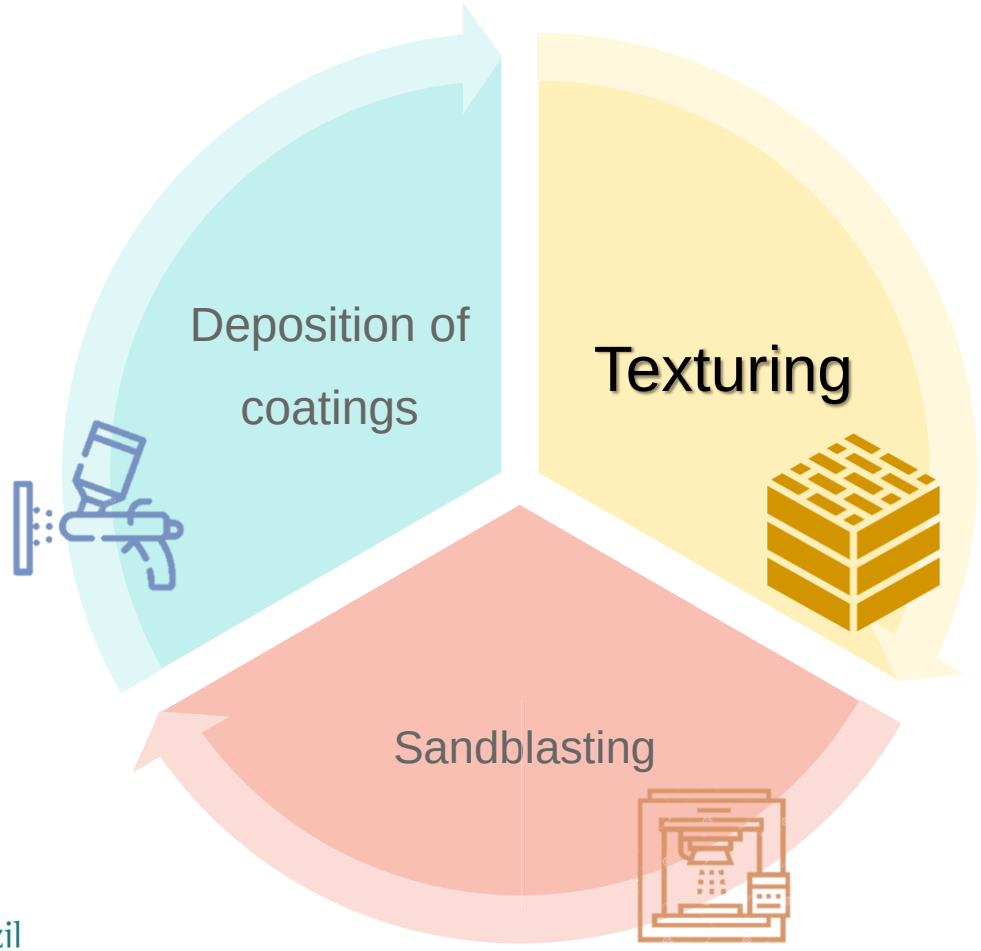
1. Motivation

SURFACE ENGINEERING



1. Motivation

SURFACE ENGINEERING



Electron beam

Electric arc

Laser ablation

1. Motivation

SURFACE ENGINEERING

Laser surface texturing

+

316L stainless steel

Contents lists available at ScienceDirect

Optics & Laser Technology

journal homepage: www.elsevier.com/locate/optlastec

Full length article

Laser surface texturing of 316L stainless steel in air and water: A method for increasing hydrophilicity via direct creation of microstructures

Sepehr Razi [a], Khosro Madanipour [b,c,*], Mahmoud Mollabashi [a]

[a] Department of Physics, Iran University of Science and Technology, Tehran, Iran
[b] Optics, Laser and Photonics Institute, Amirkabir University of Technology, Tehran, Iran
[c] Optical Measurement Laboratory, Amirkabir University of Technology, Tehran, Iran

Influence of different laser processing conditions and atmospheres in the roughness, wettability, and hydrophilicity of the surface

1. Motivation

SURFACE ENGINEERING

Laser surface texturing

+

316L stainless steel

The International Journal of Advanced Manufacturing Technology (2020) 109:1059–1069
https://doi.org/10.1007/s00170-020-05639-6

ORIGINAL ARTICLE

Check for updates

Comparing the adhesion strength of 316L stainless steel joints after laser surface texturing by CO_2 and fiber lasers

Chiara Mandolfino[1] · Muhannad Obeidi[2] · Enrico Lertora[1] · Dermot Brabazon[2]

Received: 11 March 2020 / Accepted: 15 June 2020 / Published online: 11 July 2020

Effect of the type of laser (CO_2 and fiber lasers) on adhesion strength

1. Motivation

SURFACE ENGINEERING

Laser surface texturing

+

316L stainless steel

Contents lists available at ScienceDirect

Tribology International

journal homepage: http://www.elsevier.com/locate/triboint

Production of a laser textured 316L stainless steel reinforced with CuCoBe + diamond composites by hot pressing: Influence of diamond particle size on the hardness and tribological behaviour

A. Cunha [a,*], R. Ferreira [a], B. Trindade [b], F.S. Silva [a], O. Carvalho [a]

[a] CMEMS – Center for Microelectromechanical Systems, University of Minho, Azurém, 4800-058, Guimarães, Portugal
[b] CEMMPRE – Center for Mechanical Engineering, Materials and Processes, University of Coimbra, Rua Luís Reis Santos, 3030-788, Coimbra, Portugal

MATERIALS AND MANUFACTURING PROCESSES
2020, VOL. 35, NO. 9, 1032–1039
https://doi.org/10.1080/10426914.2020.1758331

Taylor & Francis
Taylor & Francis Group

Reinforcement of a laser-textured 316L steel with CuCoBe-diamond composites through laser sintering

A. Cunha[a], R. Ferreira[a], B. Trindade [b], F. S. Silva [a], and O. Carvalho [a]

[a]CMEMS – Center for Microelectromechanical Systems, University of Minho, Guimarães, Portugal; [b]CEMMPRE – Center for Mechanical Engineering, Materials and Processes, University of Coimbra, Coimbra, Portugal

Laser surface texturing to incorporate a metal matrix composite with the aim of improving the tribological properties

1. Motivation

TYPES OF LASERS

10.64 µm

CO_2

1064 nm

YAG

848 nm

Diode

1. Motivation

TYPES OF LASERS

10.64 µm

CO_2

1064 nm

YAG

848 nm

Diode

*The **type of laser** must be selected according to the **material** to be texturing*

1. Motivation

MAIN GOAL

Produce **textures** to

improve the properties

of the final component

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MAIN GOAL

Produce **textures** to

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of the final component

TRIBOLOGICAL PROPERTIES

- *Reduce wear* (reservoir for the lubricant)

OTHER PROPERTIES

- *Reinforced with other materials* (ceramics or intermetallic compounds)

1. Motivation

MAIN GOAL

Influence of **processing parameters** on the **shape** and **surface finish** of the produced cavities (dimples)

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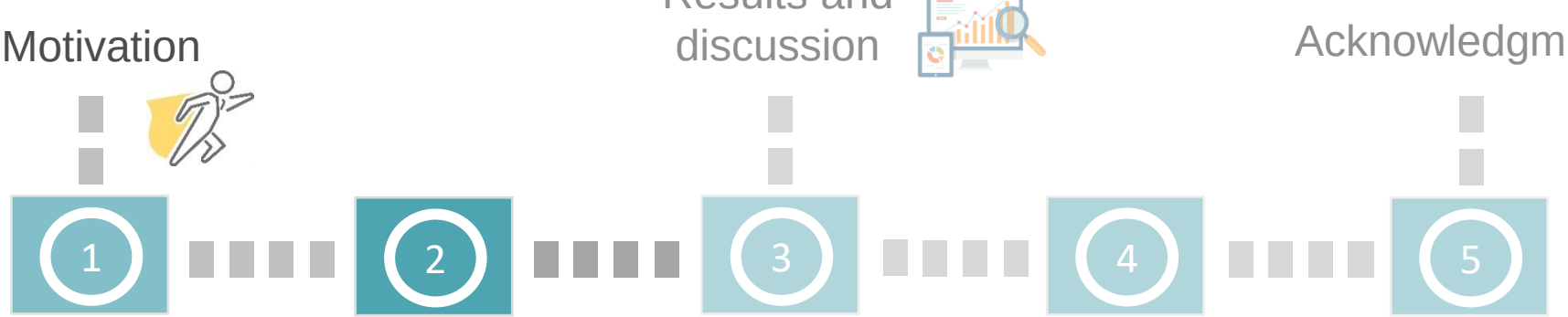
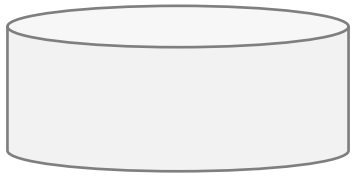


2. Materials and methods

MATERIAL

1

Samples of 316L stainless steel



Diameter: 14 mm

Thickness: 3 mm

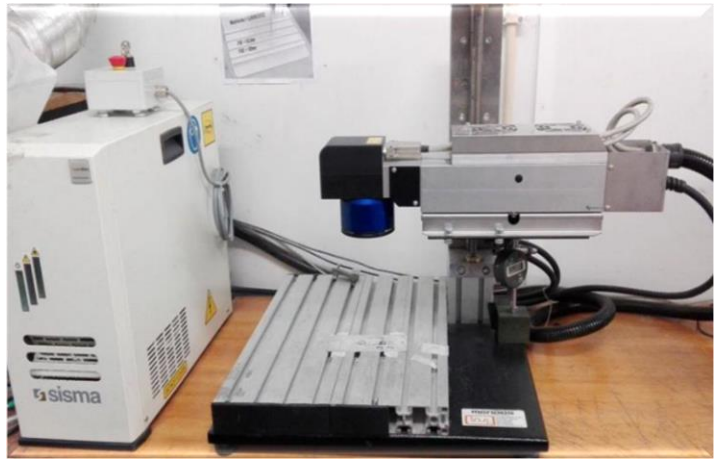
2. Materials and methods

EQUIPMENT and DESIGN

2

Surface texturing of the 316L stainless steel samples

EQUIPMENT



Nd: YAG laser

(Sisma Laser)

Wavelength: 1064 nm

Pulse width: ~35 ns

Maximum power: 6W

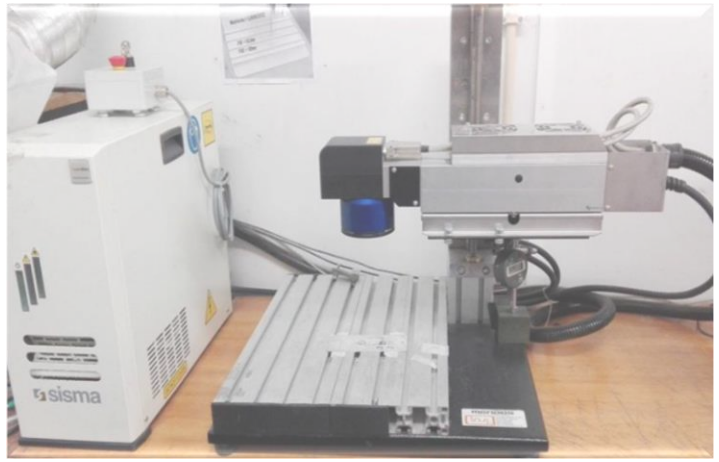
Spot: 3 µm (diameter)

2. Materials and methods

EQUIPMENT and DESIGN

2 Surface texturing of the 316L stainless steel samples

EQUIPMENT



Nd: YAG laser

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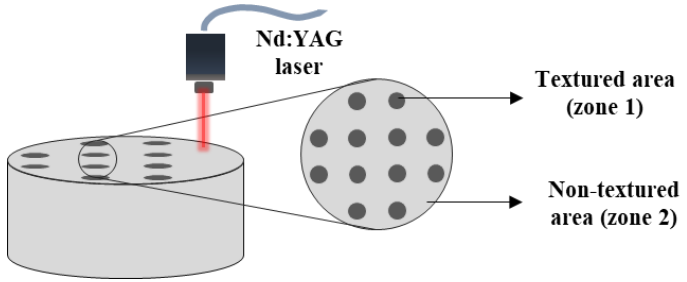
DESIGN



Dimples

- ✓ *Concentric circles*
- ✓ *Machining strategy: inside (center) to the outside (periphery)*

2. Materials and methods

STUDIES

Surface texturing of the 316L stainless steel samples

Influence of **processing parameters** on the **dimensions** of the cavity

2. Materials and methods

STUDIES

2 Surface texturing of the 316L stainless steel samples

2.1 Influence of **processing parameters** on the **dimensions** of the cavity

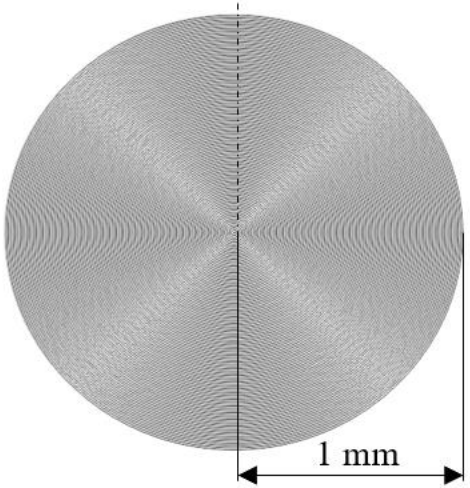
Power (6 and 3 W)

Scan speed (256 mm/s)

Number of passes (1, 2, 4, 8, 16)

Width

Depth



Distance between successive lines: 5 µm

2. Materials and methods

STUDIES

2 Surface texturing of the 316L stainless steel samples

2.2 Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples

2. Materials and methods

STUDIES

2 Surface texturing of the 316L stainless steel samples

2.2 Influence of the **size factor** and how the laser parameters affect the **width, depth** and **surface finish** of the dimples

Power (6, 3, 1.5 and 0.75 W)

Scan speed (256 and 128 mm/s)

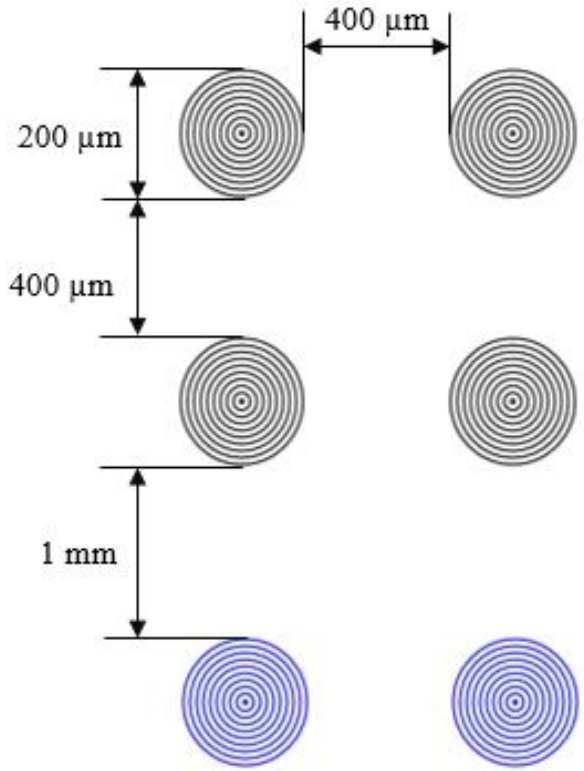
Number of passes (1, 2, 4, 8, 16, 32, 64 and 128)

Wobble

Width

Depth

Surface finish



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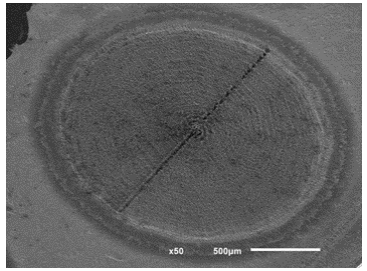
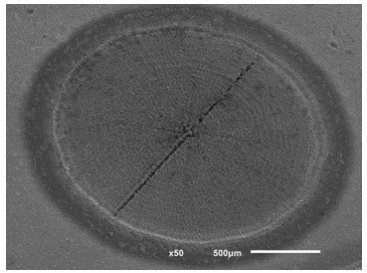
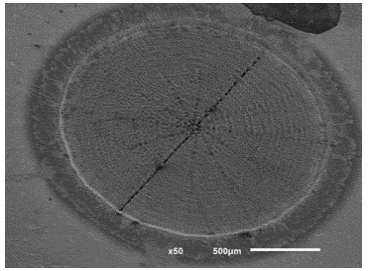
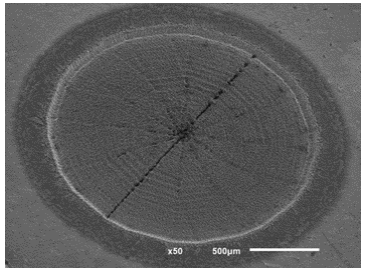
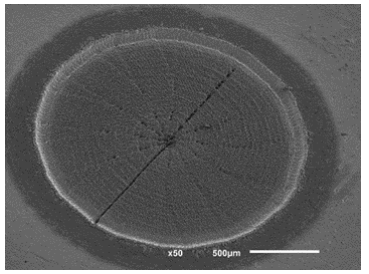
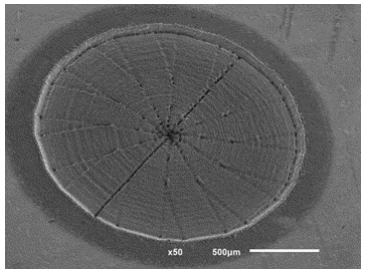
First study

*Influence of **processing parameters** on the **dimensions** of the cavity*

3. Results and discussion

First study

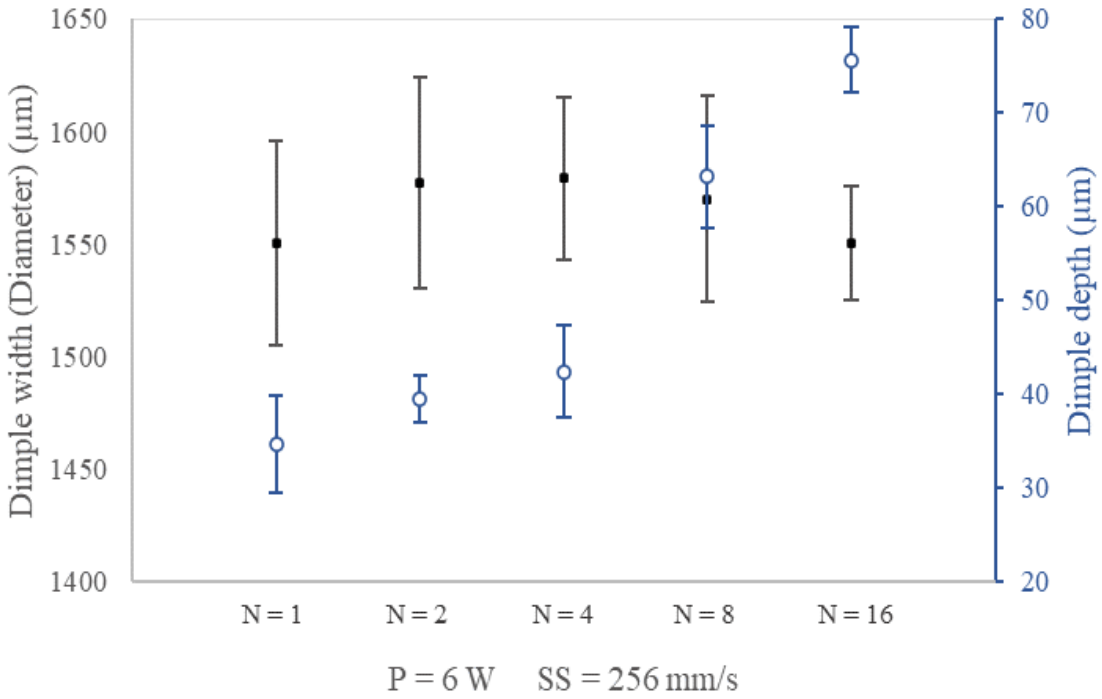
*Influence of **processing parameters** on the **dimensions** of the cavity*

	1 pass	2 passes	4 passes	8 passes	16 passes
Power: 6 W *Scan speed:* 256 mm/s					
Power: 3 W *Scan speed:* 256 mm/s					

3. Results and discussion

First study

*Influence of **processing parameters** on the **dimensions** of the cavity*



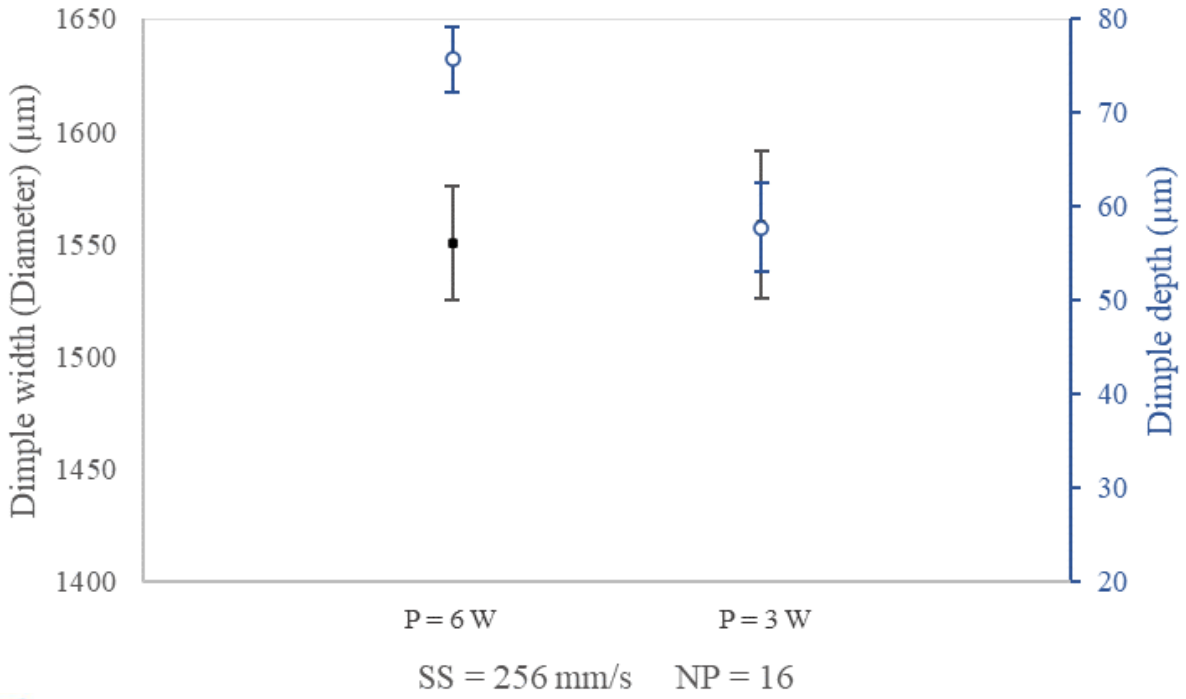
Number of passes

- ✓ No influence on the width
- ✓ Depth linearly increases as the number of passes increases (R^2 = 0.9445)

3. Results and discussion

First study

*Influence of **processing parameters** on the **dimensions** of the cavity*



Power

- ✓ The width is not qualitatively altered
- ✓ Depth increases sharply with increasing power (from 57.80 to 75.67 µm)

3. Results and discussion

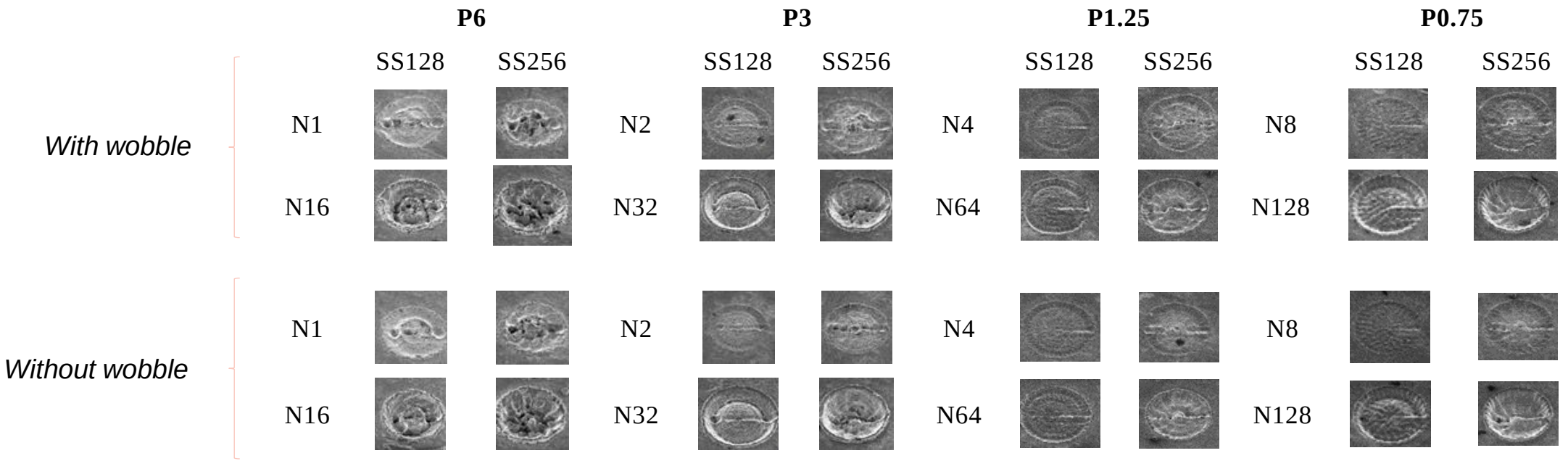
Second study

Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples

3. Results and discussion

Second study

Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples



3. Results and discussion

Second study

Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples

Size factor → Great influence on the surface finish

↑ size of draw  *↑ surface finish*

3. Results and discussion

Second study

Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples

Size factor → Great influence on the surface finish

↑ size of draw ↑ surface finish

Surface finish not influenced by…

wobble

The combination of the laser processing parameters reveals substantial changes

3. Results and discussion

Second study

Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples

Size factor → Great influence on the surface finish

↑ size of draw *↑surface finish*

Surface finish not influenced by…

wobble

BUT

The combination of the laser processing parameters reveals substantial changes

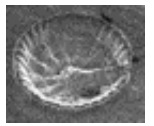
Lower power

+

Higher number of passes

** → Higher surface quality

P6 SS256 N16



P0.75 SS256 N128

** But with the same energy

3. Results and discussion

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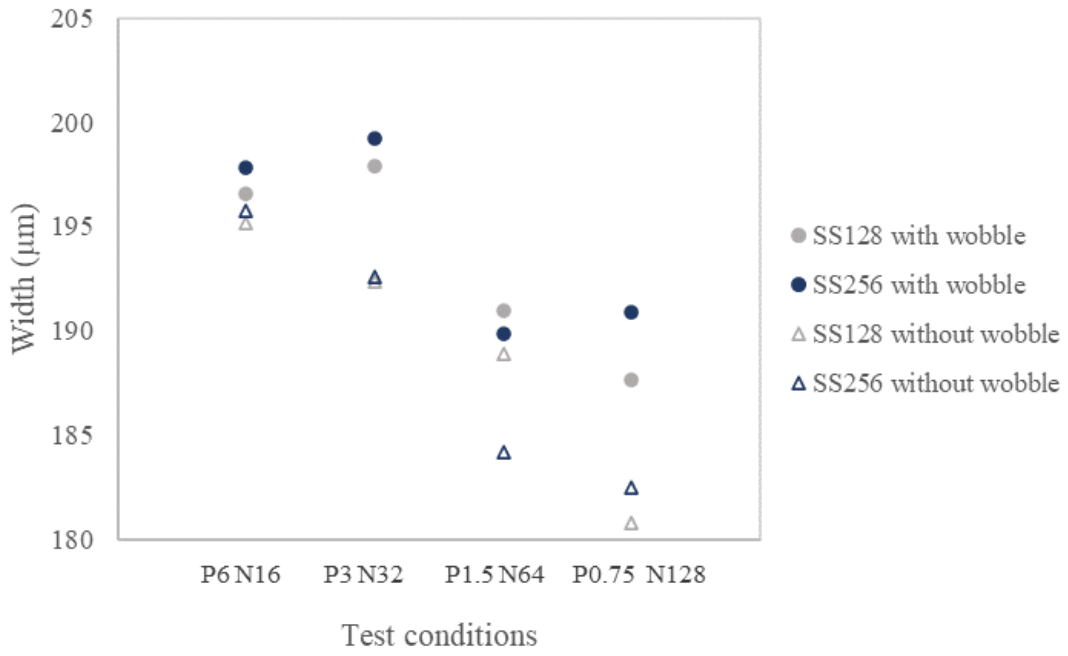
Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples



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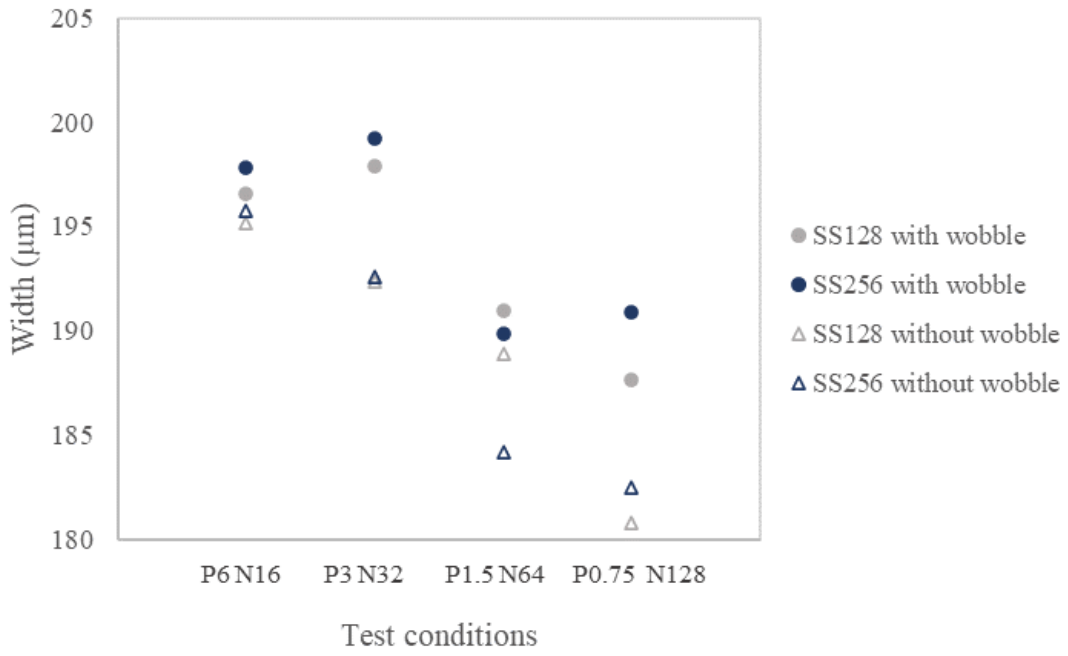
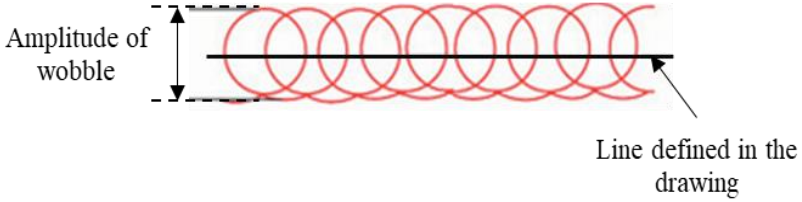
Second study

Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples



Wobble

✓ Increase the width of the cavity



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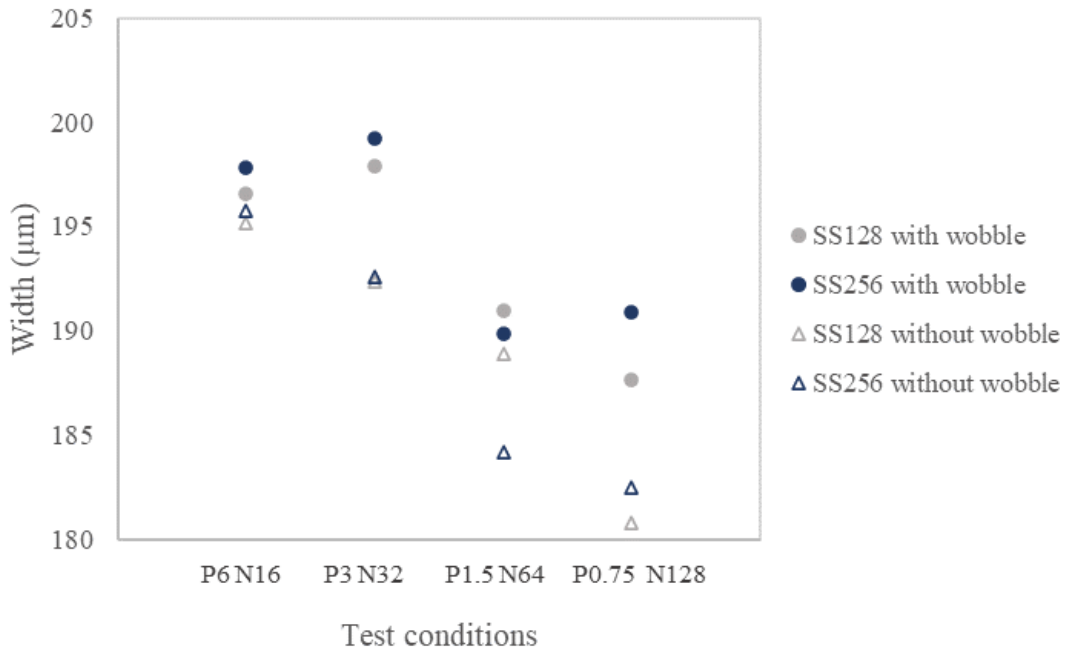
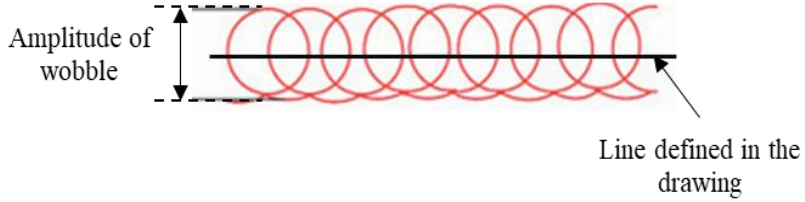


Wobble

- ✓ Increase the width of the cavity



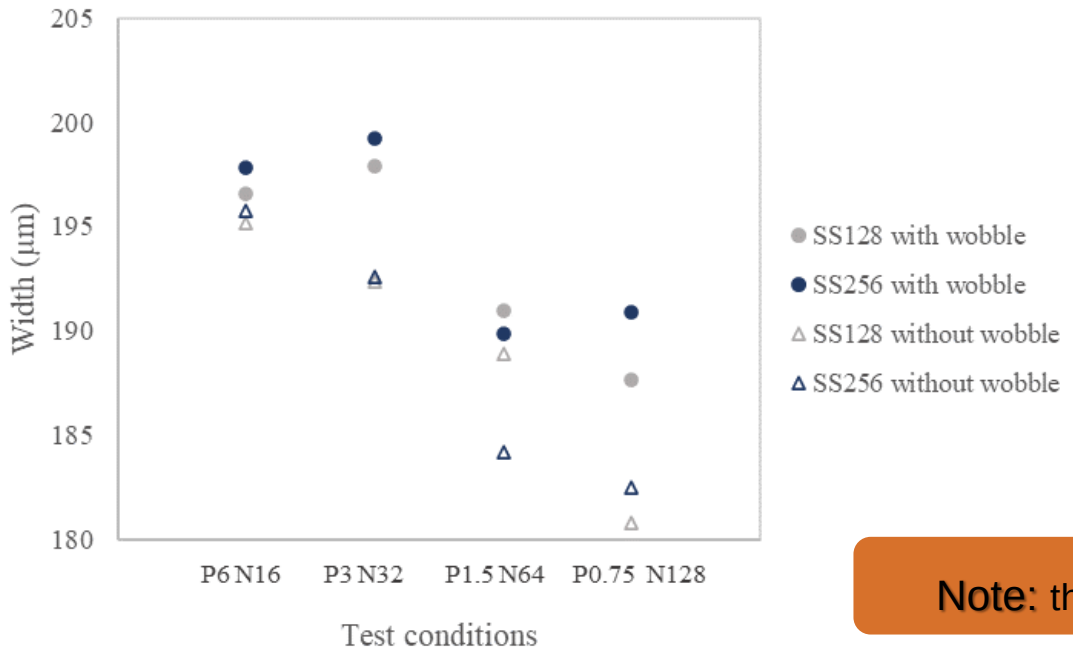
Scan speed

- ✓ Do not strongly influence the cavity width

3. Results and discussion

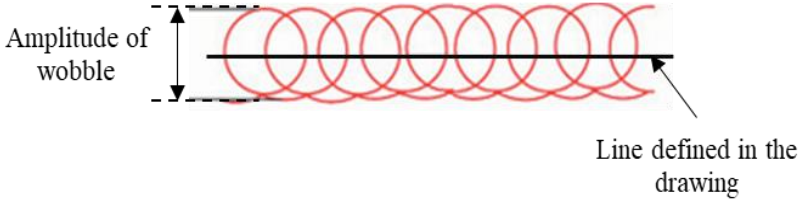
Second study

Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples



Wobble

- ✓ Increase the width of the cavity



Scan speed

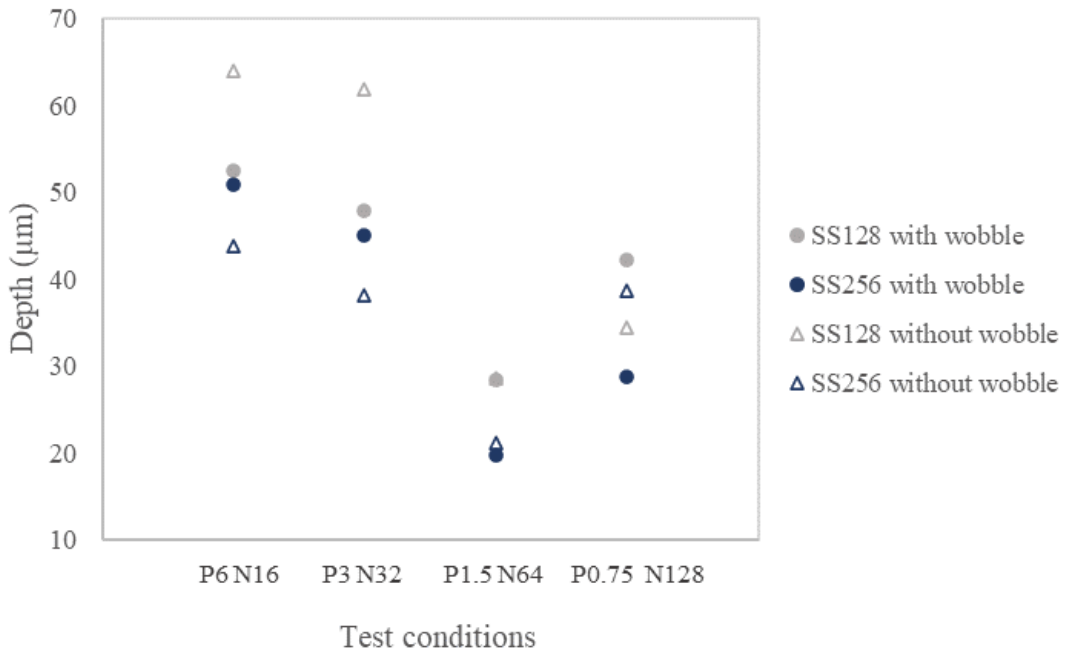
- ✓ Do not strongly influence the cavity width

Note: the influence of the power and number of passes could not be studied

3. Results and discussion

Second study

Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples



3. Results and discussion

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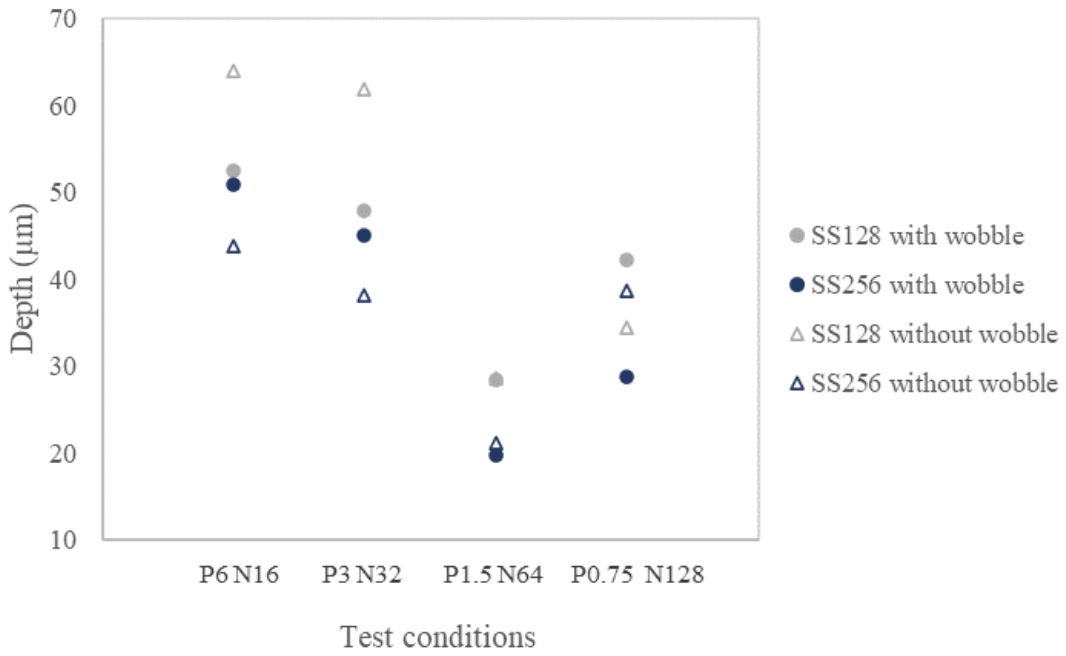


Wobble

- ✓ No relation

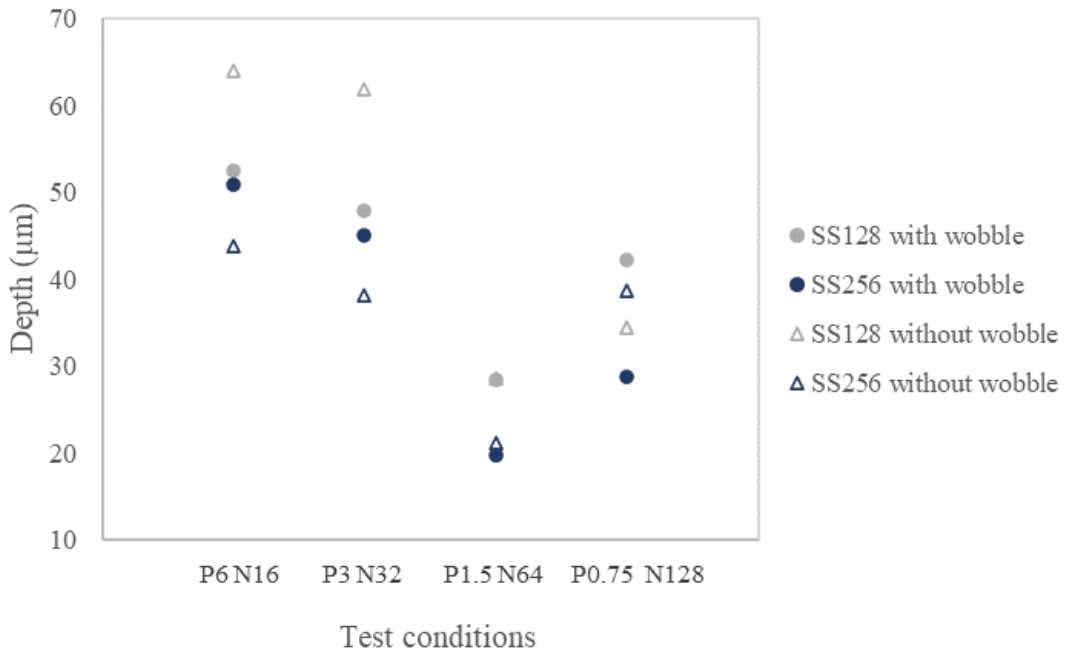
Scan speed

- ✓ Depth decrease with the increase of scan speed

3. Results and discussion

Second study

Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples



Scan speed

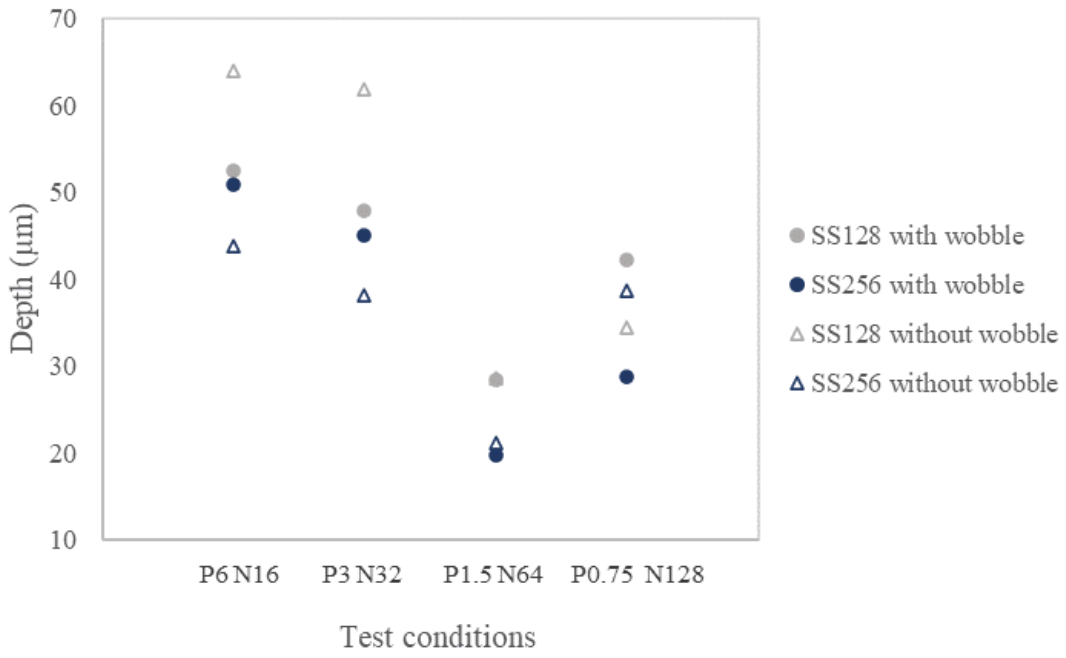
Increase of scan speed → Decrease the number of pulses generated on the unit line → Reduction of material removed from the surface

Decrease of the depth of the cavity

3. Results and discussion

Second study

Influence of the size factor and how the laser parameters affect the width, depth and surface finish of the dimples



Scan speed

Decrease of scan speed → Increase the interaction time between the laser beam and the irradiated surface → Increase of the laser energy

Increase of the depth of the cavity

Contents

4. Conclusions

- ✓ The laser parameters have a great influence on the geometrical definition and depth of the dimples
- ✓ The wobble have a more pronounced effect on the width of dimples as compared to scan speed
- ✓ The power, number of passes and scan speed strongly affected the depth of cavities produced

Contents

5. Acknowledgments

This work was supported by FCT (Fundação para a Ciência e a Tecnologia) national funds, under the national support to R&D units grant, through the grant SFRH/BD/147460/2019, the project UIDB/04436/2020 and UIDP/04436/2020 and, also by project UIDB/00285/2020 .

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Universidade do Minho

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31st August 2021

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