Influence of the Process Parameters on the Densification and Microstructure of Ni-based Superalloys with Different Amount of Former Alloying Elements Processed by SLM

Influence of the Process Parameters on the Densification and Microstructure of Ni-based Superalloys with Different Amount of γ' Former Alloying Elements Processed by SLM

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Framework

Ni-based superalloys are characterized by high-temperature strength, oxidation and corrosion resistance making them excellent for several applications such as aerospace and chemical sectors. Additive manufacturing (AM) processes, in particular laser powder bed fusion, allow the fabrication of complex parts in a single step resulting attractive for Ni-based superalloys.

This work investigates the effect of different process parameters on the densification and microstructure of various Ni-based superalloys, Tab 1, characterized by increasing amounts of γ' former alloying elements, studying the balance between pores and cracks reduction and the resulting microstructure. The involved parameters are: laser power, scanning speed, hatching distance. The scanning strategy used is "stripes" as shown in Figure 1

Tab. 1 Studied Ni-based superalloys composition [1]

Alloy	Cr	Co	Mo	W	Ta	Nb	Al	Ti	C	Hf
CM247 LC	8	9.3	0.5	9.5	3.2		5.6	0.7	0.07	1.4
Renè 80	14	9	4	4			3	4.7	0.16	0.8
Inconel 939	22.4	19		2		1	1.9	3.7	0.15	

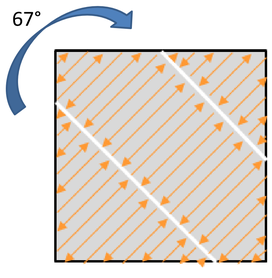

Fig. 1 Top view of the stripes scan strategy

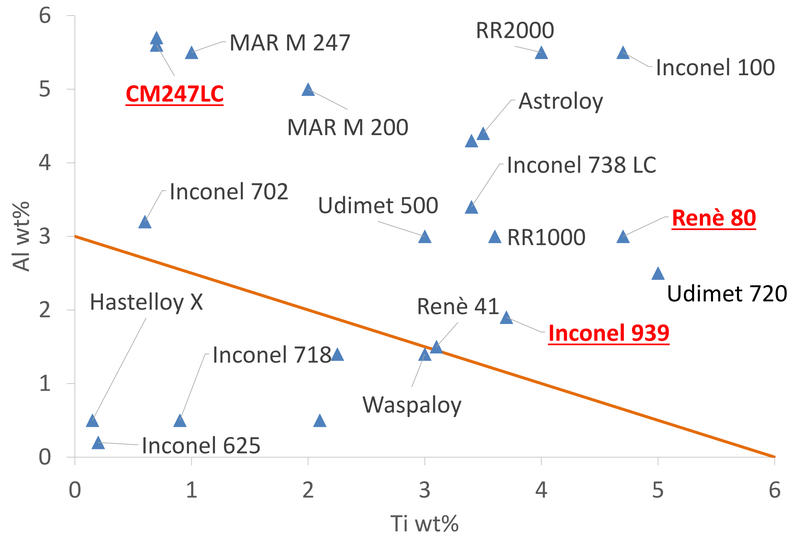

Figure 2. Theoretical weldability diagram according PWHT cracking mechanism [2]

VED Vs Porosity

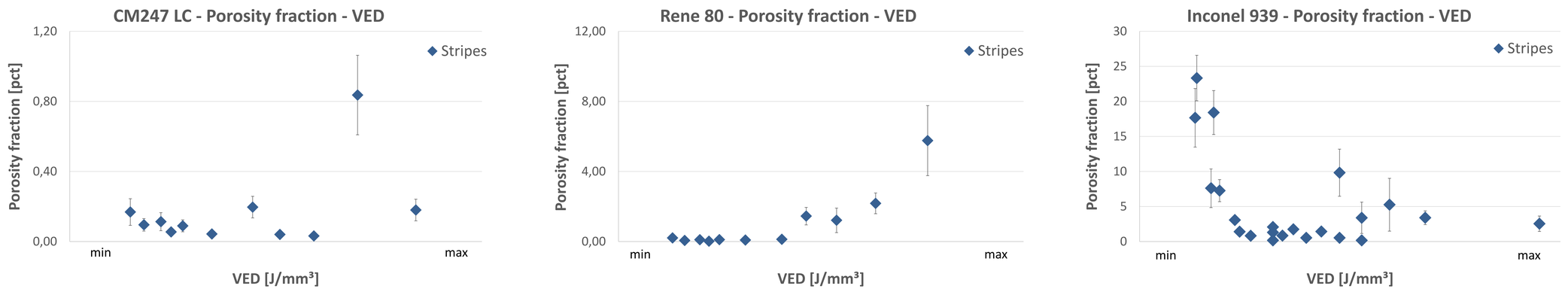

Figure 3. Show the effect of the VED on the pores fraction among the studied composition. From left to right, CM247LC, Rene80, Inconel 939

$$VED = \frac{P}{v\ hd\ t}\left[\frac{J}{mm^3}\right]$$

Paraemters effect on crack density

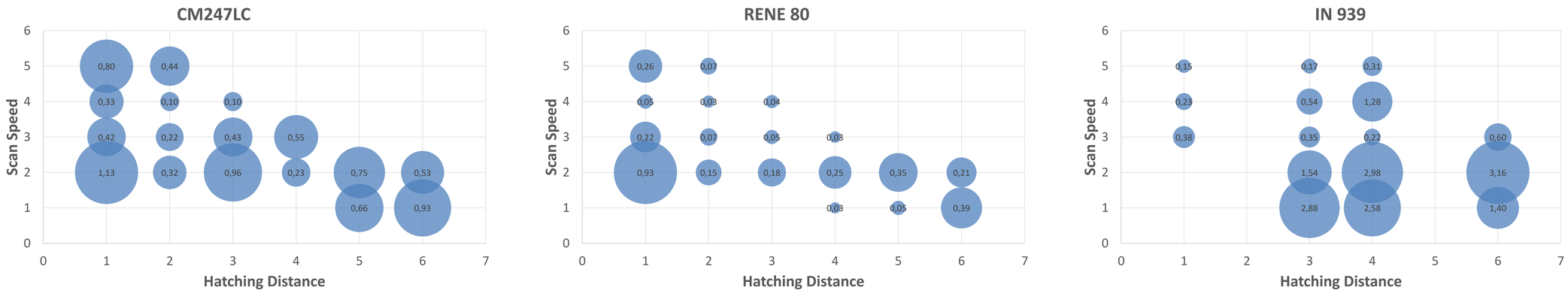

Figure 4. Effect of hatching distance and scans peed on the crack density, expressed in reduced values and keeping the power constant

MIcrostructure

Figure 5. Macrostructure obtained after mixed acid etching. Shows the columnar grains, vertically oriented, the meltpool and the thermal cracks parallel to the grains

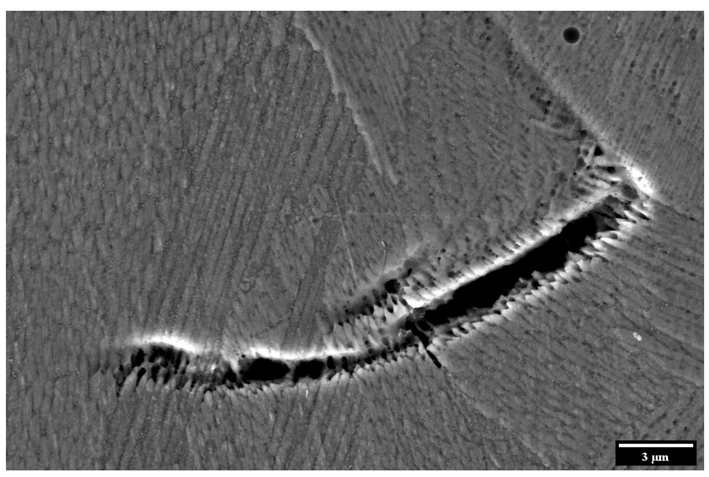

Figure 6. SEM microstructure a lack of fusion void surrounded by the typical pattern of the cellular structure that develops inside the grains

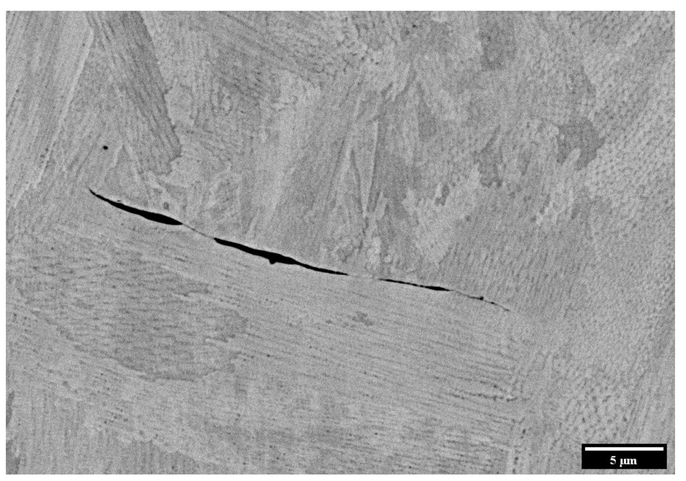

Figure 7. SEM microstructure of a thermal crack grown on a grain boundary.

References

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[2] M. Moattaz Attallah, Jennings, «Additive manufacturing of Ni-based superalloys: the outstanding issues», MRS Bullettin, 2014 (41)

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