3d Live Pool 27 Crack 15 PORTABLE

fig. 10 shows a scatter plot for both the void and defect fractions (%) as well as crack density that is represented by crack length per unit cross-sectional area (mm/mm2) against laser power density (w/mm2) in the slm fabrication of ti-6al-4v titanium alloy [28]. as seen from the figure, with an increase in laser power density, more material is melted, void fraction is quickly reduced, especially when the laser power density exceeds 700w/mm2. a similar result can be acquired from the calculation results by different research groups on laser power density calculation for the slm fabricated titanium parts, but the appropriate laser power density is different due to different materials [7, 22, 28, 47 52]. conversely, the crack density shows a slight increase with the increase in laser power density due to the large thermal stress caused by the excessive laser power. the geometry of the molten pool has been demonstrated to be an important parameter in the slm process. in the uls process, the molten pool geometry is determined by the solidification front movement, and the development of the solidification front is dependent on the production rate [6, 45]. the formation of a solidified layer between the adjacent tracks depends on the time that the molten pool has been able to maintain its molten state before the solidification front has reached the last track [29]. if the time is not enough, a solidified layer is formed and attached to the last track. the molten pool solidifies from the last track, and the metal solidified layer becomes large [7]. in the slm process, the solidification front moves towards the base of the molten pool, which is very different from the uls process [45, 46]. the thermal conductivity of the molten pool is low [47]. the heat transfer from the liquid metal to the substrate is therefore slow, and the shape of the molten pool changes slowly during the solidification process. this causes the molten pool to have a thin shell, which leads to a high cooling rate around the molten pool [7, 29]. moreover, the internal pressure of the molten pool is low, which contributes to the formation of a spherical-shaped porosity. figure 1 shows a simulation result of a molten pool with a lower internal pressure. figure 1. simulation result of a molten pool with a lower internal pressure. the field of view is 100 µm × 100 µm. the scan speed is 1250 mm/s. figure 2 shows a simulated molten pool with a higher internal pressure. figure 2. simulation result of a molten pool with a higher internal pressure. figure 3 shows a simulation result of a molten pool with a lower cooling rate. figure 3. simulation result of a molten pool with a lower cooling rate. figure 4 shows a simulation result of a molten pool with a higher cooling rate. figure

4. simulation result of a molten pool with a higher cooling rate. the reasons for porosity defects associated with the molten pool geometry have been studied and explained by many researchers [4, 28].

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fig. 6 shows the defect morphology in an slm fabricated aluminum part. (a) the oblique incident sem image of the surface reveals that many porosities are present on the surface, which seems to be caused by discontinuous metal powder coverages during the slm process. (b) the sem image of the cross section reveals that many incomplete fusion holes are also present inside the fabricated part [42]. as compared with the crack in an slm titanium part, the crack in an slm aluminum part tends to initiate from the incomplete fusion holes. more cracks are formed in the side near to the fusion holes than that far from the fusion holes, indicating that the temperature gradient is more significant around the fusion holes than that far from them. fig. 7 (a) shows a powder bed fusion (pbf) fabricated titanium part with a riser-tower configuration. the sample height is 2.4 mm and the cover-to-cores ratio is 0.63. fig. 7 (b) shows the different parts on the surface. black parts represent the unfused metal powders and the white parts represent the fused metal powders. although the sample surface is covered with a number of unfused metal powders, cracks are rarely found on the surface. this is because the metal powders were covered with excess fused metal powders during the melting process, forming pores that were filled with fused metal powders. the unfused metal powders were also fused in the pores. the high temperature gradient in the pores created by the fused metal powders created a thermal stress that resisted crack formation [27]. fig. 7 (c) shows a fracture morphology of the partially fused metal powders. the white part represents the fused metal powders and the black part represents the unfused metal powders. the unfused metal powders are fully fused in the white part. the surface is highly porous and there are cracks between the fused metal powders. these cracks were made by molten metal that flowed out of the pores. the pores were also filled with fused metal powders, preventing crack formation. fig. 7 (d) shows an as-built part of an slm fabricated specimen. the as-built surface is highly porous and there are cracks between the fused metal powders. the pores formed in the as-built surface were caused by excessive accumulation of unfused metal powders on the surface, which prevented crack formation in these parts. the as-built surface is also covered with unfused metal powders. the unfused metal powders were fused in the pores during the melting process, which formed pore-filled unfused metal powders. 5ec8ef588b

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