L.7: Improvement in mechanical strength of maraging steel by laser shock peening

The maraging steel is used as structural material for various applications due to its ultra-high strength and better toughness. The ultra-high strength is achieved due to precipitation hardening caused by intermetallic compounds formation during the aging process. To meet current industry demand, the development of maraging steel using laser based additive manufacturing (LAM) is widely pursued as it has the capability to produce near net shape and custom-made 3D metal components. It is found that difference in thermal history of LAM fabricated components due to layer by layer deposition results in the generation of tensile residual stresses leading to premature cracks, which in turn reduces the static and dynamic strength. To enhance the mechanical strength of LAM built maraging steel, laser shock peening (LSP) is used as post processing tool. In view of the above, in the present study, the effect of LSP parameters on residual stress, hardness and tensile property is studied.

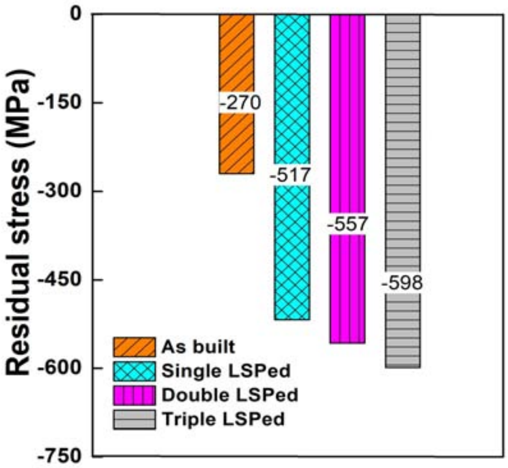

Fig. L.7.1: Residual stress measured in as built and LSP treated samples.

The built maraging steel samples are laser peened using an in-house developed Q-switch Nd:YAG laser at laser power density of ~3.5 $GWcm^{-2}$ for single, double and triple LSP impacts, while fixing other peening parameters such as laser spot size (3 mm), repetition rate (2 Hz) and overlap percentage (70%). Post to LSP treatment, it is found that for single LSP impact, the compressive residual stress is increased to -517 MPa as compared to -270 MPa for as built sample and for triple LSP impact, the maximum surface residual stress is observed around -598 MPa (refer to Figure L.7.1). Thus, we observe that increase in the laser impacts increases the compressive residual stress. Further, LSP treatment resulted in increase in hardness of maraging steel and this can be witnessed from Figure L.7.2. In the case of as built sample, the hardness is observed in the range of 395 to 400 HV, however, post to single peening, the hardness on the surface is increased to 415 HV. With increase in LSP impacts, the hardness is found to be further increased and its maximum value of 425 HV is observed for triple LSP impacts. Moreover, across the depth, the hardness is found to be gradually reducing and reached to the base value at the depth of 175 µm and 250 µm for single and triple LSP impacts, respectively.

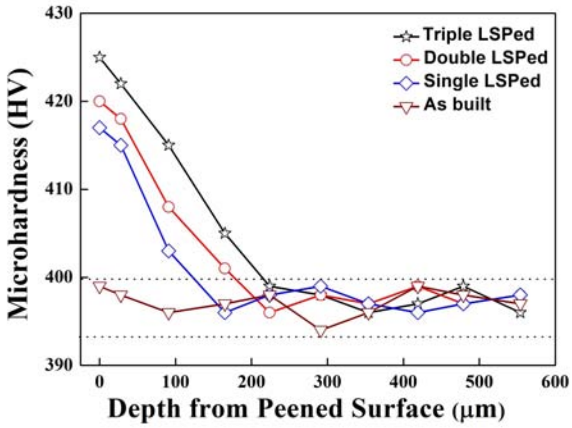

Fig. L.7.2: Hardness measured across the cross-section of laser peened and unpeened samples.

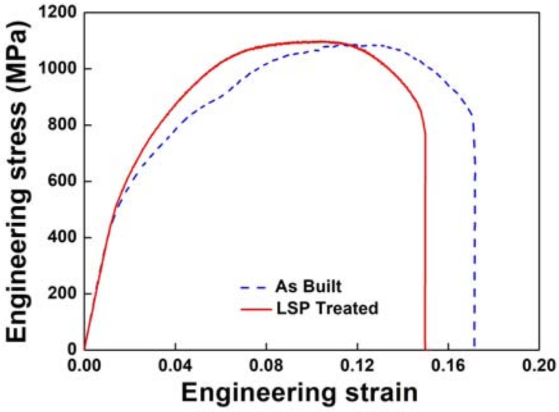

Fig. L.7.3: Engineering stress-strain plot of as built and LSP treated samples.

The effect of triple LSP treatment on tensile properties of maraging steel is also studied. The engineering stress-strain curve of as built and triple LSP treated samples is displayed in Figure L.7.3. No appreciable change in linear region (elastic region) for both samples suggest that Young's modulus of the maraging steel is independent of microstructure. However, the yield strength (YS) is found to be higher for LSP treated sample. The YS in triple LSP treated sample increased to 850±14 MPa as compared to as built sample (753±10 MPa). A small change in ultimate tensile strength (1082±62 MPa to 1120±48 MPa) is also observed. Increase in YS is attributed to the strain hardening caused by interaction of moving dislocation and diffusive solute atoms during the multiple LSP impacts. In summary, it is found that LSP treatment led to significant improvement in compressive residual stress, hardness and tensile properties of LAM built maraging steel.

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