

Thermal stability and wear behaviour of AISI S2 tool steel processed by Laser Powder Bed Fusion

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Thermal stability and wear behaviour of AISI S2 tool steel processed by Laser Powder Bed Fusion

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This study investigates the thermal stability and wear behaviour of AISI S2 tool steel processed by Laser Powder Bed Fusion. The processability of this material was previously examined in a separate study conducted by the same team. Isothermal treatments up to 10 hours were performed on as-built samples at three different temperatures (200 °C, 300 °C, and 400 °C), in order to investigate the thermal stability. The alloy is thermally stable at 200 °C and 300 °C, whereas its microstructure and properties change at 400 °C. Pin-on-disc campaigns were conducted at room and high temperatures. The wear sequence of the material at room temperature was elucidated, following the approach of interrupted wear tests. High-temperature wear tests were conducted at the same temperatures as those of the isothermal treatments. The wear behaviour at 200°C and 300°C were found to be similar to that at room temperature, while the wear behaviour at 400 °C was markedly different, including the formation of a thick oxide layer and of a tribolayer that protect the surface from further wear. The results showed an increased wear rate at high temperatures compared to that at room temperature. These analyses were conducted using optical and scanning electron microscopy, DSC, pin-on-disc, profilometer, and macro and nano-indentation techniques.

The following figures have been used in the results chapter to investigate thermal stability. Additionally, they have been included in the discussion for the analysis of the most significant results obtained in this project.



Figure 1: OM micrograph samples post-etching. a) sample treated at 200°C for 10 hours; b) sample treated at 300°C for 10 hours and c) sample treated at 400°C for 10 hours.

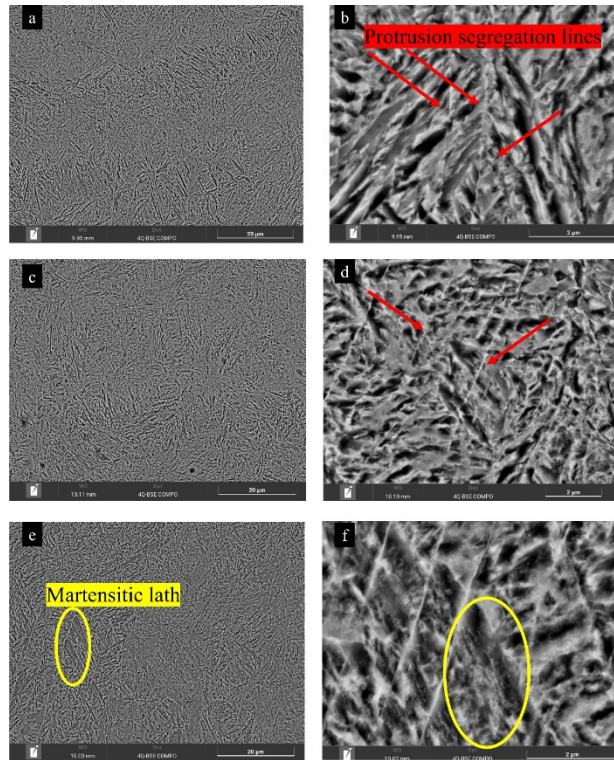


Figure 2: SEM micrographs of 10 hours isothermal treated samples at magnification of 20 µm and 2 µm in scale from left to right. a) and b) samples treated at 200°C; c) and d) sample treated at 300°C; e) and f) sample treated at 400°C.

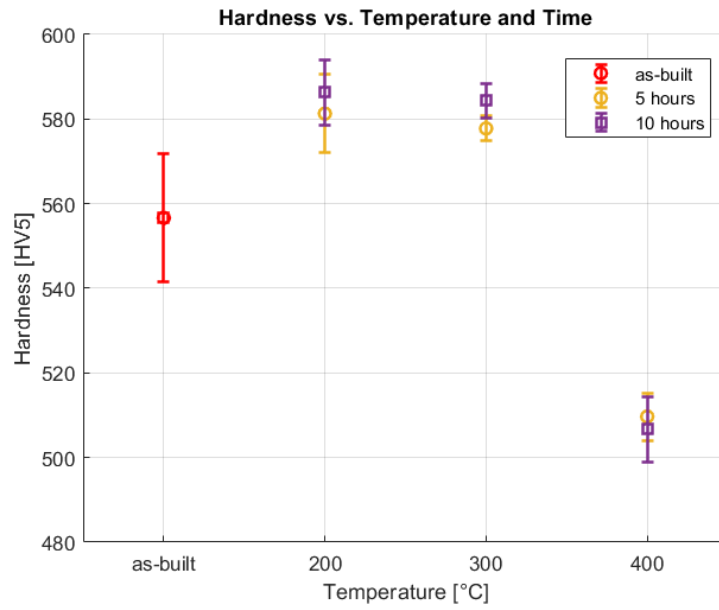


Figure 3: Hardness vs Temperature and time graph. The hardness is in HV5

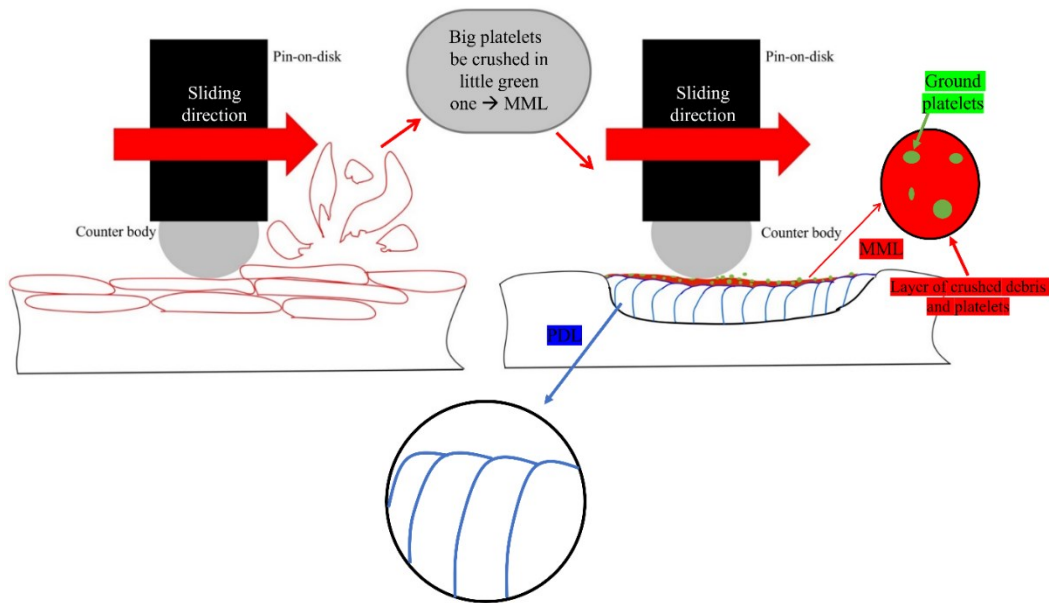


Figure 4: Sketch of MML formation. Platelets were detached, grind, and then formed the MML over the PDL.

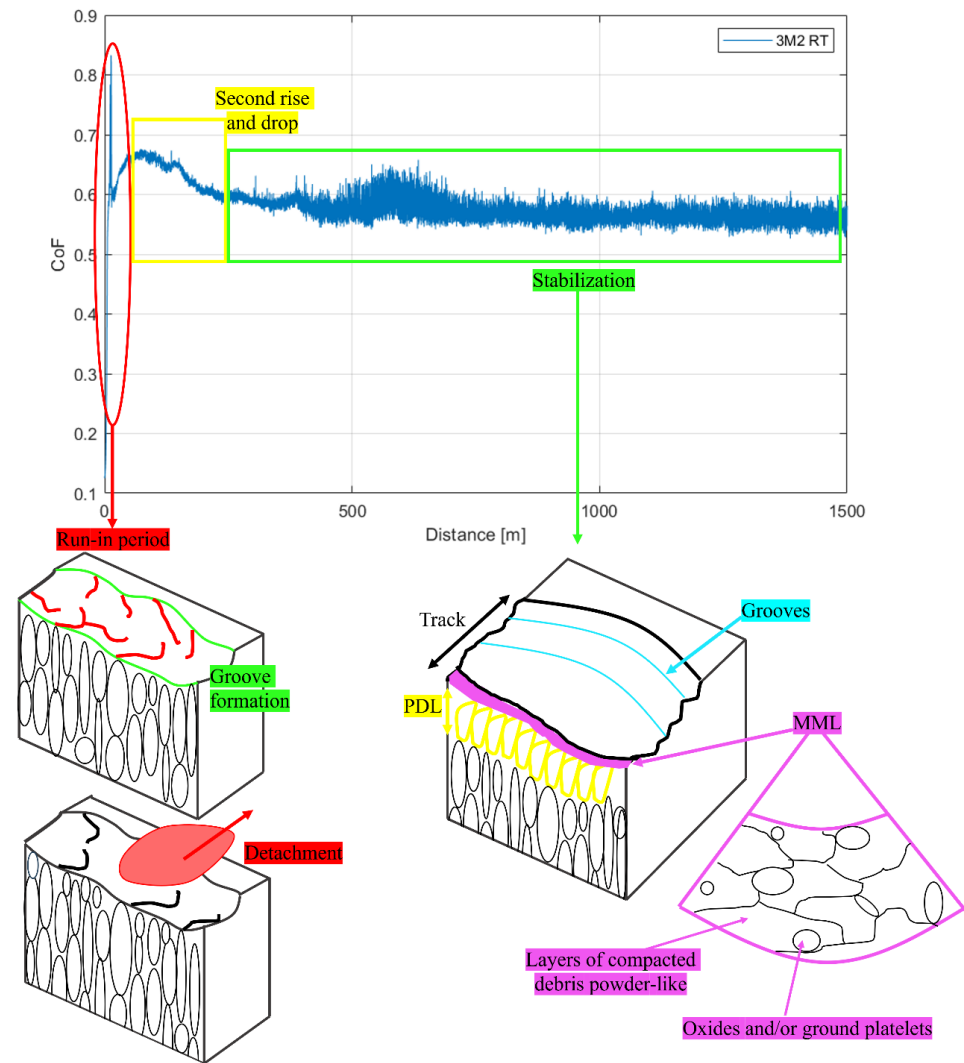


Figure 5: Sketch of the microstructure evolution during the RT test.

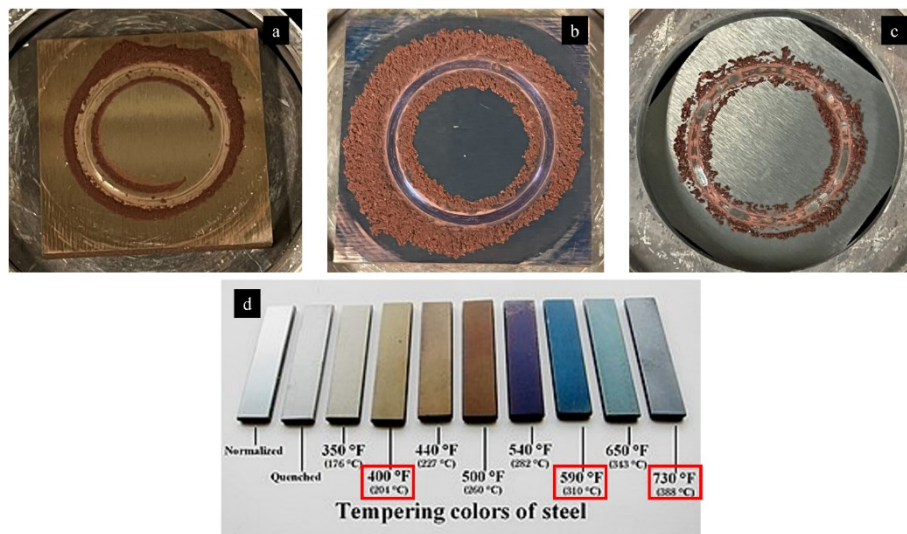


Figure 6: a) wear test at 200°C, showed yellow; b) wear test at 300°C, showed blue; c) wear test at 400°C showed grey; d) tempering steel chart is reported with a highlight on the three temperatures of the wear tests that are consistent with the results.

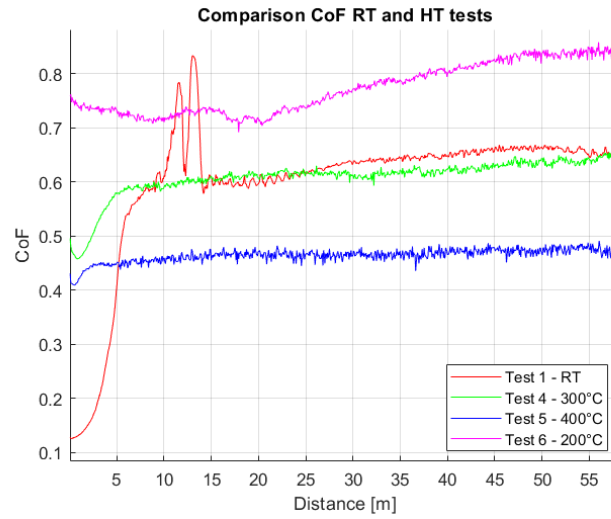


Figure 7: Comparison between Coefficient of Friction of RT and HT tests.

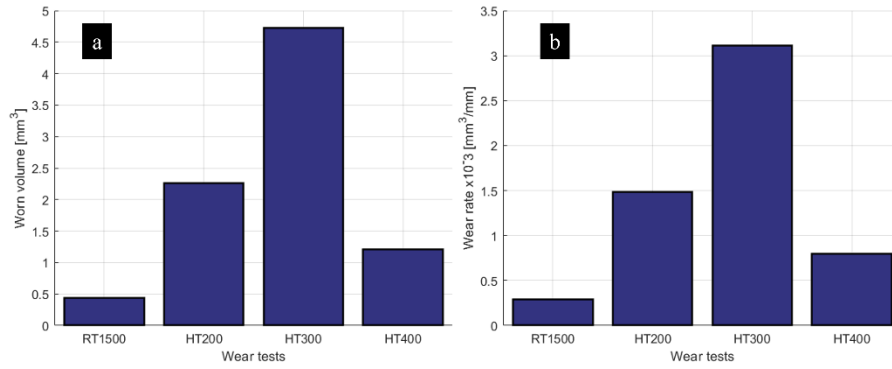


Figure 8: Worn volume and b) wear rate comparison of the four long tests.

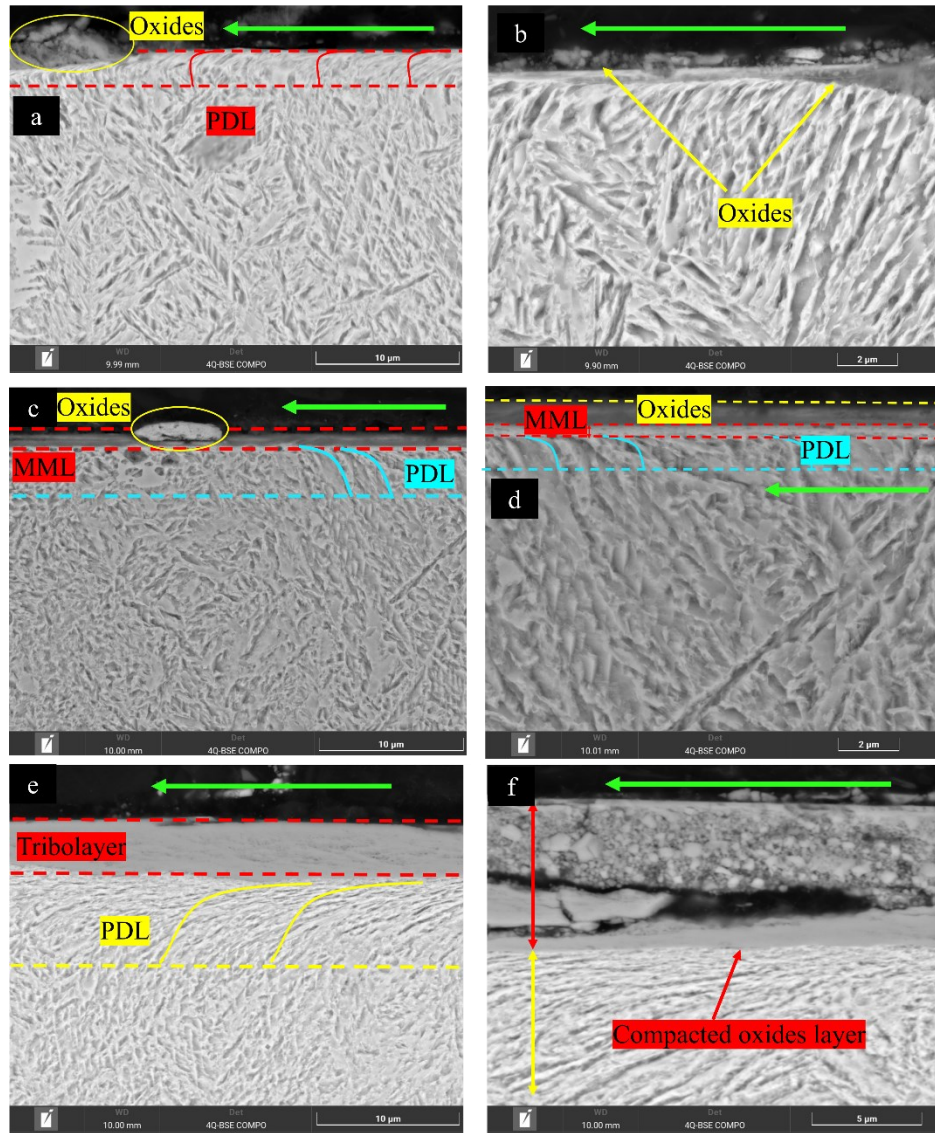


Figure 9: SEM micrograph of the subsurface of the wear track. Green arrows indicate the sliding direction of the wear tests. a) and b) HT200 test; c) and d) HT300 test; e) and f) HT400 test.

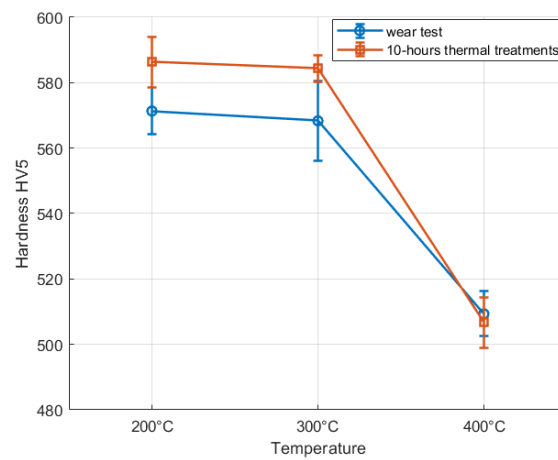


Figure 10: Macro-hardness comparison between HT wear tests and 10-hours thermal treatments.