Linear Friction Welding (LFW) is a solid-state joining process producing narrow joints mainly developed for the aircraft industry. The thermo-mechanical loads involved in LFW lead to significant local microstructural changes. This study aimed at identifying the mechanisms impacting these changes in order to develop a Post-Weld Heat Treatment (PWHT) optimizing the joint microstructure. The temperature fields showed that a zone of 1mm on either side of the weld center line experienced thermo-mechanical processing in the β-domain for 2 s followed by a rapid cooling to 400 °C. Inspection of the weld by Optical Microscopy (OM) and Scanning Electron Microscopy (SEM) revealed a strongly affected microstructure characterized by a sharp microstructural refinement and the presence of defects at the interface. The joint consists of: 1) the Welding Line (WL) which underwent a complete α→β transformation accompanied by the recrystallization of the prior-β grain and the development of a {110}<111> texture followed by intragranular precipitation of textured α′ Hexagonal Close-Packed (HCP) martensitic laths; 2) the Thermo-Mechanically Affected Zone (TMAZ) characterized by a partial α→β transformation resulting in a microstructure refinement by α variant selection upon cooling. A third zone, the Heat Affected Zone (HAZ), was revealed as having a microstructure indistinguishable from the base material (BM) but being slightly harder. The texture analysis of the reconstructed β phase in the joint core showed that the local deformation conditions were asymmetrical between the forging and the oscillating part and that the WL may have experienced a complex material stirring with turbulent flow. These microstructural changes generate an increase in hardness in the joint with a maximum increase of HV0.3 by 40% in the WL. The PWHT consisting of an α+β annealing followed by ageing resulted in an α′→α+β decomposition and α globularization in the TMAZ leading to a gradual microstructure refinement from the BM to the WL. A rather homogenous hardness was obtained across the assembly after the PWHT.