Some Aspects of tribology of Ti6Al4V fabricated by Selective Laser Melting Additive Layer Manufacturing

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Résumé

Selective Laser Melting (SLM) is one of the several challenging advanced Additive Layer Manufacturing (ALM) for 3D-tailoring metallic materials and structures. SLM employs the powder as the "raw" material. In general the metallic powders have spherical shape with fine microstructures due to their rapid solidification providing them a good of the alloy elements distribution and microstructural homogeneity. During SLM processing laser beam transfer a huge quantity of the energy to metallic material in part in the form of powders and in part in already form solid. In fact powder is spread-out layer-by-layer alike bed on the previously 3D-built up layers. Both powders and already solidified material close and under-surface of the laser spot area are conjointly exposed to this energy. In fact a "micro-molten" bath is rapidly formed and very rapidly re-solidified. The microstructure feature of SLM materials are resulted form a multiple "micro-casting". Depending on processing parameters (spot size, laser energy and its distribution, laser spot travelling speed, the deposited powder inter-layer distance, the distance between separating the successive laser weld beads, the strategy of laser beam scanning and the temperature of the manufacturing tray, etc.) and the chemical composition as well as size and morphology of powders, different microstructures are obtained. Generally, theses microstructures are cellular or dendritic depending on crystallography nature (e.g. cubic or hexagonal, etc.) of the alloy and the local solidification conditions. More or less columnar or equi-axial grains are formed. A more or less anisotropic 3D-structure is built. Il is now well established that the final surfaces of SLM-materials are tortuous in as-fabricated conditions. The post-fabrication machining and/or polishing (chemical, mechanical or thermo-chemical) are required. Another well established facts in SLM processing is the presence of the various micro-cavities or micro-shrinkages in terms of form, dimension and orientation vis à vis the 3D-building direction. This contribution deals with the first investigations at room temperature of the tribological behavior of Ti6Al4V fabricated by a SLM-Solution 125HL machine. Cylindrical pins with conical heads and "flatten" surfaces are built-up in 3-orientations (0◦, 45◦, 90◦) according the manufacturing tray surface. Experiences are performed on pins in as-fabricated conditions. Prior testing, the surface of the pins are roughly softly polished with abrasive in order to insure a well planarity of their surface of the contact. The other surfaces of pins are not machined or polished. Low carbon steel XC18 is used as the rotating discs. The surfaces of the pins are analysed by SEM and OPM prior and post-mortem. Pins are cross-sectioned parallel

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to the sliding direction for microstructural analysis inward the contact surface. The micro-hardness is measured from contact surface inward and or parallel to the sliding direction. The As-fabricated SLM microstructure is constituted of "patches" with martensite features. The layer beneath the pin surface experiences the tremendous shear plastic straining and accumulation. Gradient of elongated dendritic/cellular and martensite microstructure features decorate and delimit clearly the shear plastic flow lines. The microstructures in-depth the pin surface, self-adapt to shear plastic loadings according to their local specific crystallographic orientations of micro-grains or patches with the loading and sliding directions. Even if the "macroscopic" (global) ductility of SLM materials is lower than conventionally processed Ti6Al4V, nevertheless under-layer of pin surfaces shows a "high potential" for plastic accommodation and local "ductility". Versus the 3-orientations of fabrication, it is noted that friction coefficients are closed and the wear rates (mm3/N.m) present differences. The initial defects and cavities are also sheared. The ductile micro rupturing leads also to form the new cavities.

Mots-Clés: Ti6Al4V, tribological behavior, Selective Laser Melting, room temperature, pin on disc tribometer