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Metallurgical and Machinability Characteristics of Wrought and Selective Laser Melted Ti-6Al-4V

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ABSTRACT

This examination work shows a machinability ponder between created review titanium and specific laser softened (SLM) titanium Ti-6Al-4V in a face turning operation, machined at cutting paces in the vicinity of 60 and 180 m/min. Machinability attributes, for example, device wear, cutting powers, and machined surface quality were examined. Covering delamination, attachment, scraped spot, steady loss, and chipping wear instruments were overwhelming amid machining of SLM Ti-6Al-4V. Greatest flank wear was discovered higher in machining SLM Ti-6Al-4V contrasted with fashioned Ti-6Al-4V at all rates. It was likewise found that high machining speeds prompt disastrous disappointment of the cutting instrument amid machining of SLM Ti-6Al-4V. Cutting power was higher in machining SLM Ti-6Al-4V when contrasted with fashioned Ti-6Al-4V for every single slicing pace because of its higher quality and hardness. Surface complete enhanced with the cutting pace in spite of the high instrument wear seen at high machining speeds. By and large, machinability of SLM Ti-6Al-4V was discovered poor when contrasted with the created compound.

Keywords: machinability, thermomechanical, titanium

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INTRODUCTION

Titanium compound Ti-6Al-4V is broadly utilized as a part of aviation, vehicle, marine, and biomedical enterprises as a result of its high quality to weight proportion, high erosion resistance, and great biocompatibility [1]. At present, fashioned handling speaks to the cutting edge innovation for creating titanium compounds with microstructure and mechanical properties important for basic applications. However fashioned parts are costly for use in many applications, due to the multistep, vitality serious, thermomechanical handling courses utilized. Along these lines, powder metallurgy and added substance fabricating have for quite some time been looked for as a way to diminish generation expenses of Ti amalgams, attributable to added substance producing innovations close net shape abilities and different beneficial components [2]. Added substance fabricating has picked up consideration among analysts and assembling enterprises in view of its profitable abilities, for example, opportunity of configuration, on-request producing, diminished crude material wastage, and low vitality utilization [3]. In the most recent decade, a few added substance producing systems for preparing of metals were proposed. Some of these procedures utilize wire as introductory material (e.g., molded metal affidavit) and others utilize metallic powders (e.g., particular laser sintering (SLS), specific laser dissolving (SLM), and electron shaft softening (EBM)) [4, 5]. Each of these advances has its own particular points of interest and drawbacks. SLM is portrayed by medium profitability and great repeatability and thus it is viewed as an appropriate technique for direct assembling of amazing parts with low to medium amount [6]. Titanium parts manufactured utilizing specific laser softening are in effect broadly utilized as a part of different fields, for example, biomedical inserts and dental inserts [7]. What is more, SLM manufactured parts likewise have colossal potential in the aviation and car ventures [8]. It was likewise found that Ti-6Al-4V sections created from SLM handle (henceforth alluded to as SLM Ti-6Al-4V) have higher yield quality, rigidity, and hardness contrasted with fashioned Ti-6Al-4V [9, 10]. Murr et al. [11] announced high quality and hardness of SLM Ti-6Al-4V are for the most part because of the martensite stage administrations show in its microstructure. As a result, the malleability in SLM Ti-6Al-4V is discovered fundamentally bring down contrasted with created Ti-6Al-4V supported by its curious microstructure and porosity [9].

WORK MATERIALS

Two sorts of titanium composites were utilized as a part of this review; these were fashioned review Ti-6Al-4V and added substance fabricated SLM Ti-6Al-4V (specific laser softened). Fashioned Ti-6Al-4V was made by hot rolling, trailed by postannealing heat treatment at 730°C (2 hours) and air cooled. SLM Ti-6Al-4V was manufactured utilizing SLM 125 HL machine in an argon air. Both materials were manufactured in empty barrel frame. Created Ti-6Al-4V had an equiaxed microstructure structure while SLM Ti-6Al-4V comprised of a fine acicular microstructure with grain development toward building. It is found that this acicular microstructure offers ascend to high quality and hardness of SLM Ti-6Al-4V over fashioned Ti-6Al-4V [9]. The martensite stage exhibit in the acicular microstructure of added substance made titanium combinations accordingly of quick warming and cooling because of the way of the manufacture procedure offers ascend to its higher quality and hardness [11].

Machining Parameters

The machinability of the work materials was tried utilizing face turning strategy. This machinability test strategy is particularly intended for testing the machinability of powder metallurgy materials. The machining test strategy was done at three cutting paces (mm/min) beginning at 60 m/min, then 120 m/min, lastly 180 m/min, with steady bolster rate (0.5) of 0.1 mm/rev and profundity of cut (.56) of 0.5 mm.

RESULTS AND DISCUSSIONS

Machining trials found selective laser melted titanium alloy SLM Ti-6Al-4V machined with higher tool wear, cutting forces, and machine surface roughness compared to wrought Ti-6Al-4V. This difference in machinability characteristics of these materials can be attributed to the higher strength and hardness of SLM Ti-6Al-4V over wrought material due to its peculiar acicular microstructure [12–20].

CONCLUSIONS

Face turning tests were performed on wrought and additive manufactured Ti-6Al-4V using PVD coated carbide tools. Machinability of these two differently processed materials was studied and compared for different speeds. Machinability was characterized in terms of tool wear, cutting forces, and surface roughness. Based on Results and Discussions, the following conclusions can be made:

(i) Maximum flank wear was found to be higher during machining of SLM Ti-6Al-4V compared to wrought Ti-6Al-4V for all cutting speeds employed.
(ii) The flank wear increased rapidly at high machining speeds and led to

catastrophic failure of the cutting tool during machining of SLM Ti-6Al-4V.

(iii) Coating delamination, adhesion, abrasion, attrition, and chipping were found to be the dominant tool wear mechanisms during machining of SLM Ti-6Al-4V.

(iv) Cutting forces are found to be higher during machining of SLM Ti-6Al-4V due to its high strength and hardness as compared to wrought Ti-6Al-4V.

(v) Surface roughness decreased with increase in cutting speed during machining of both the materials, despite the high tool wear observed. SEM images of the machined surface reveal that the surface becomes smoother with cutting speeds.

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