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Effects of Processing Conditions on Powder Particle Size and Morphology in the Mechanical Milled H13 Alloy

V.H. Mercado-Lemus[1*], J.A. Betancourt-Cantera[1]*, J.E. García-Herrera[2], R. Pérez-Bustamante[1], Jan Mayen[2], A. Gallegos-Melgar[1], M. Hernandez-Hernandez[1], L.A. Caceres-Díaz[2] and D.G. Espinosa-Arbeláez[3].

[1]CONACYT – Corporación Mexicana de Investigación en Materiales, Saltillo, Coahuila de Zaragoza, México,
[2]CONACYT – Centro De Tecnología Avanzada, San Luis Potosi, San Luis Potosi, México,
[3]CONACYT – CIDESI – Consorcio de Manufactura Aditiva, CONMAD, Querétaro, México
* Corresponding author: jbetancourt@comimsa.com; vic_210583@yahoo.com.mx

The H series steels are usually used for manufacturing dies with properties capable of withstanding the high loads and temperatures of forging [1]. For example, the H13 steel is one of the most widely used steels for hot and cold work tooling applications, widely used in the manufacturing of molds and dies. It is a chromium, molybdenum, vanadium hot work steel containing up to 0.4 wt.% of carbon, strengthened by martensite and carbides [2].

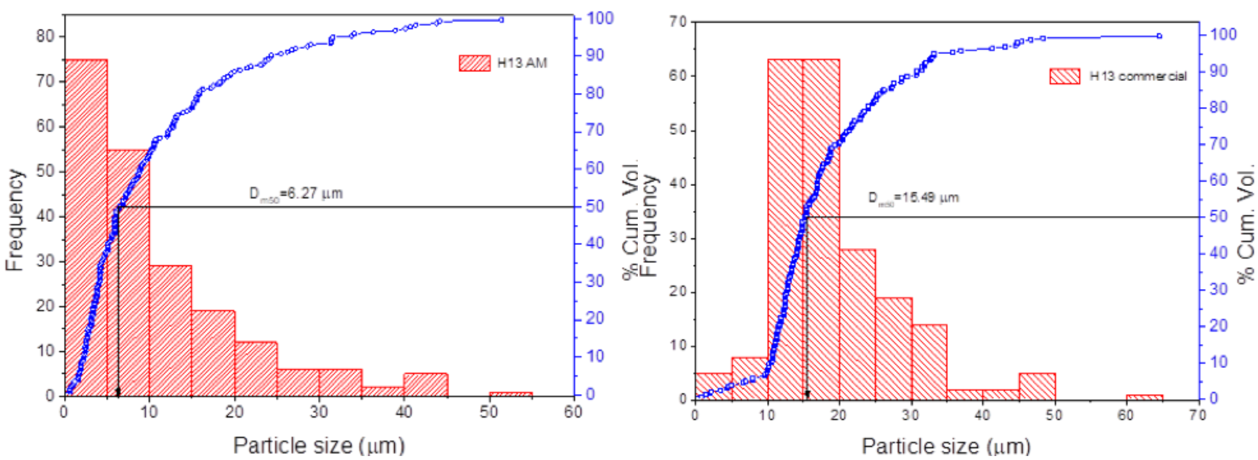
The use of H13 in additive manufacturing (AM) has been exploited building consecutive layers of powders for the manufacturing of parts or components with improved mechanical and tribological properties. AM has gained significant importance due to the different characteristics obtained in terms of mechanical performance, solving various defects or faults at a surface level, making possible even geometric recovery [3]. Powders, as raw material, are fundamental in this technique. Such powders can have different sizes and morphologies depending on their production process. The characteristics of the powders and parameters used in additive manufacturing, provide the final product with the mechanical aspects to be improved.

On the other hand, mechanical alloying can produce alloys and powder compounds. Through repeated welding, fracturing and re-welding cycles, it can produce difficult or impossible alloys not considered in conventional melting and casting techniques. In addition, during powder milling, the particles undergo high-energy impacts by balls. These high-energy impacts result in a multitude of microstructural defects such as vacancies, dislocations, grain boundaries, and stacking faults in particles, which gives rise to nanometer crystallite size and phase transformations. In addition, it also leads to particle size variations structural and morphologic changes of the powders [4].

In the present research work, a study of the of particle size in H13 steel obtained by mechanical alloying from metal shavings and their comparison with a commercial powder obtained by atomization to evaluate the morphologic and particle size of the powders. For this purpose, a SPEX 8000D shaker mill was used for the mechanical alloying process in a controlled atmosphere at room temperature. The ball-to-powder weight ratio was 5:1 and 120 minutes of milling time. In addition, to obtain the micrographs, the Keyence VHX-970F optical 3D microscope was used to show an alternative in the characterization technique and analysis on morphology and particle size of the as-milled powders.

Figure 1 shows the results of the milling process. Figure 1 a) shows an image obtained by 3D optic of the metal chips milled for 50 minutes. It can be noticed the profile and the flake-like morphology Moreover, Figure 1 b) display the H13 as-milled steel powders. It is visualized an irregular morphology in different sizes, as was corroborated by the analysis of particle distribution shown in Figure 2 a), where is observed the particle diameter around of 6.27 µm. On the other hand, Figure 1 c) shows a commercial powder alloy. The spherical morphology of the powder can be observed, with average sizes of 15.49 µm, as corroborated by the analysis presented in Figure 2 b). The preliminary conclusion of this experiment shows that it is possible to obtain H13 powder alloys by mechanical alloying with similar particle sizes to commercial powders [5].

Figure 1. Micrographs of a) H13 powder milled at 50 minutes and visualized in 3D optic microscopy, b) H13 obtained at 120 minutes by mechanical alloyed and c) commercial powder alloy H13.



a. **b.**

Figure 2. Comparison of particle size distribution of a) H13 obtained by mechanical alloyed and b) commercial H13 alloy.

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