Development of a Sustainable Novel Aluminum Alloy from Scrap Car Wheels Through Stir-Squeeze Casting.

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Abstract

Aluminum alloys are extensively finding applications in many industries, including automotive and aerospace, because of its lightweight. However, still, Al alloys suffer from lower strength, and finding a suitable alloy composition is quite critical. In this research, a novel aluminum alloy was produced using a stir squeeze casting technique. Sustainability analysis of three competing processes to produce the alloy was carried out using Analytical Hierarchy Process (AHP) method. Based on the final scores obtained through AHP, the stir-squeeze casting was selected to produce the Al- High Entropy Alloy (HEA). The optimal conditions for the stir-squeeze casting process parameters were determined from the literature. Scrap aluminum alloy wheels (typically A356 grade) from cars were used as the matrix material. High entropy alloy (HEA) was used as the alloying element, with a total weight percentage of 2.6 %. The composition of the HEA is Al_{35} Li_{20} Mg_{15} Si_{10} Zn_{15} Ca. After the alloy is developed, mechanical properties such as hardness, tensile, wear, and compression tests were conducted. Besides, the microstructure of the developed material was studied. Optical microscope and Scanning Electron Microscope (SEM) as well were used for the analysis. Moreover, X-ray Diffraction (XRD) was carried out to analyze the phases formed during alloy development. In addition, heat treatment was done for the produced alloy, and then mechanical properties and microstructure were compared before and after heat treatment. T6 heat treatment was completed which includes two main steps, solution treatment followed by quenching and then aging. The mechanical properties before heat treatment were sufficient enough when compared to the original A356 (LM25) grade that is not heat treated. After heat treatment, there was a significant improvement in hardness and compressive strength, and this improvement is mainly attributed to the Si particle precipitation that occurred during the aging process. Both before and after heat treatment, the fracture appeared to be brittle. The reason for the brittle fracture is attributed to the accumulation of second phases in the grain boundaries, which have weak bonding with the matrix material. The developed novel Al-HEA alloy can be deployed in several applications where compressive strength is of primary importance, such as car alloy wheels, cylinder heads and blocks.

Keywords: Aluminum alloys, Sustainability, Squeeze casting, High Entropy Alloy, AHP method, T6 heat treatment

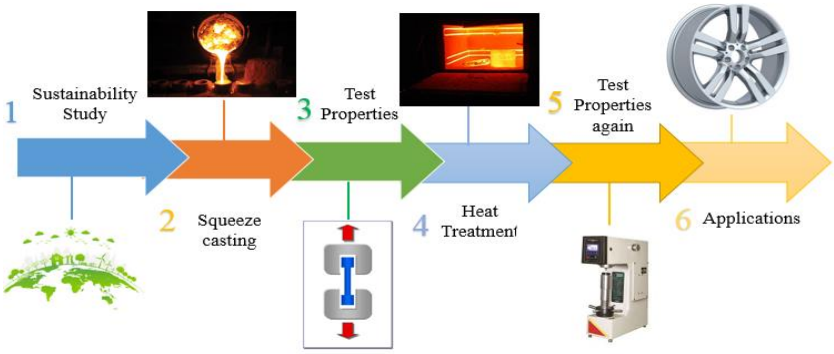

Fig. 1: Flow chart of the thesis work progress