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Fabrication of Zinc metal powders on developed Rotary Electrode Arc Atomization setup

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ABSTRACT: Zinc has been identified to exhibit ideal bio corrosion rate and is proposed to be a feasible bio-absorbable material suitable for making bio implant devices. However, the processing of zinc is very difficult due to its HCP crystal structure and unfavorable mechanical properties. High purity metal powder is an important raw material for near-netshape fabrication via powder metallurgy (PM) manufacturing route, as well as feedstock for powder injection molding, and additive manufacturing (AM). In the present research work, a low cost rotating electrode arc atomization set-up was developed to manufacture high purity zinc powders. Further, the morphology of the powders manufactured using the developed set up was analyzed under Scanning electron microscope(SEM).

I. INTRODUCTION

Zinc was identified to have excellent biocompatibility and near ideal bio-corrosion rate (between iron and magnesium) by Bowen et al. [1], and they claimed that it can be used for BMI applications. However, due to the HCP crystal structure and poor mechanical properties of zinc it is difficult to carry out post processing operations such as extrusion on the components made using zinc [2]. Powder metallurgy and additive manufacturing are emerging as alternatives in the fabrication of near-net shape components directly from powders, thereby eliminating the post processing operations [3 -5]. Production of high-quality metal powders is becoming important to meet the increasing demand for manufacturing advanced materials [6 - 9].
Keeping in view, a low cost setup for manufacturing of high quality Zn metal powders using argon gas atmosphere rotating electrode arc atomization technique was developed. The method of fabrication and the results & discussions of on the fabricated Zn metal powders are reported in detail further.

II. MATERIALS AND METHODS

Zinc electrodes in the form of rods 10 mm diameter rods fabricated from the Special High Grade (SGH) zinc were used as consumable cathodes. Tungsten electrodes in the form of rods 10 mm diameter rods were used as Non-consumable stationary anode.

A. Argon gas environment based rotary electrode arc atomization set-up

The set comprises of a sealed atomization chamber fitted on a working table. A motor is mounted on a cross slide mechanism fixed on the working table. The shaft of the motor is connected to the metal electrode (Cathode) through a nylon connector. The nylon connector ensures electrical insulation between the cathode and motor shaft. The cathode is made of the metal whose powders are to be fabricated in the process. The sealed atomization chamber is fitted with a nozzle at the top to provide a jet of argon gas required for cooling the molten metal powders and to provide an inert atmosphere to restrict oxidation of the newly formed metal powders. An exhaust nozzle is fitted for ejecting the excess argon gas. The anode is made of tungsten electrode which remains stationary. There is a power supply unit which provides electrical energy for the operation of the setup. The fabricated powders are collected at the bottom of the sealed chamber by gravity action. Fig 1 shows the detailed construction of the developed setup.

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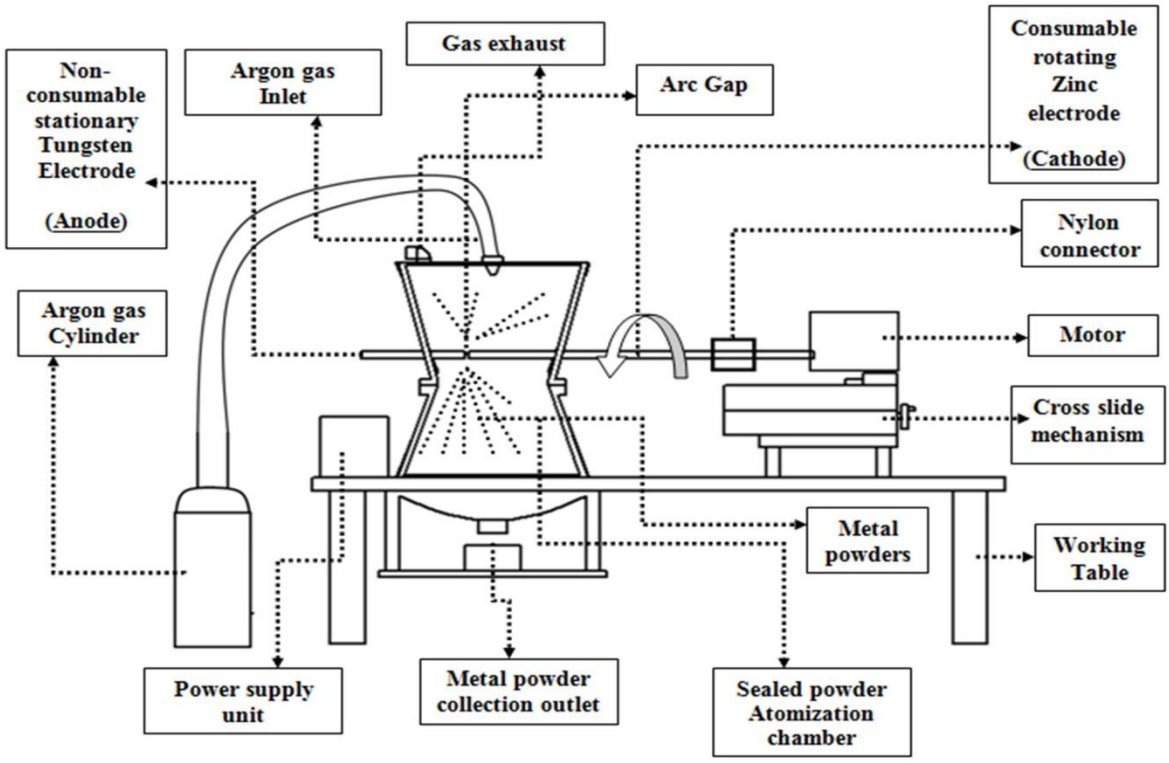

Fig. 1 Argon atmosphere rotating electrode arc atomization process

The consumable cathode was made up of Zn metal whose powders are desired to be fabricated. The cathode was connected to the shaft of a motor through a nylon connector. When the supply is switched on, the motor imparts rotations to the cathode. The rotating cathode is given a horizontal feed using the cross slide mechanism. Upon reaching a suitable gap between the rotating cathode and the stationary tungsten electrode, there is a spark across the gap. This spark melts the tip of the rotating cathode. The molten metal drops get detached from the cathode by the centrifugal force imparted by the high speed revolutions of the cathode. The molten drops of metal are cooled and subsequently solidified in a jet of argon gas. The argon gas atmosphere ensures that the newly formed metal powders are not oxidized. The solid metal powders are collected in the powder box fitted at the bottom of the sealed chamber by gravity action.

III. ANALYSIS OF THE FABRICATED METAL POWDERS

A. Chemical Composition analysis

The chemical composition of the zinc powders fabricated using the developed setup was analyzed using Energy Dispersive Spectroscopy (EDS) technique. Fig 2 shows the results of the EDS testing performed on the zinc electrodes.

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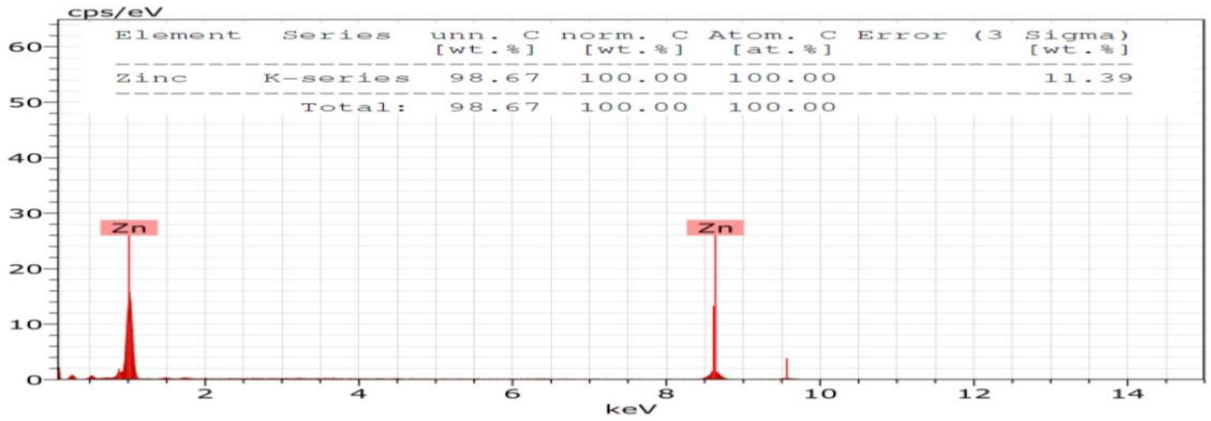
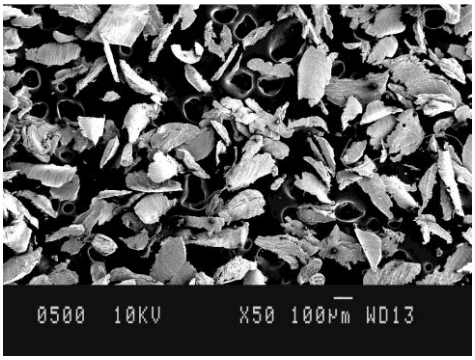


Fig. 2: EDS test result of the fabricated zinc powders

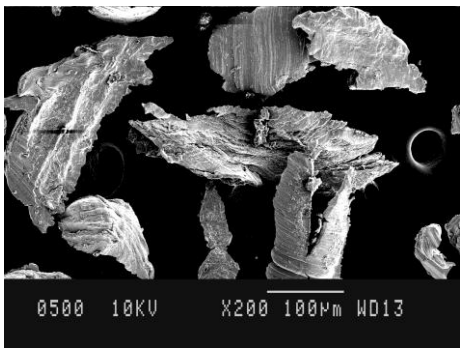
It is clear from the result of the EDS analysis of the fabricated Zn powders that oxygen content in the final composition of the fabricated Zn powders was not identified. This shows that the argon gas restricts the oxidation of the newly formed metal powders.

B. SEM analysis

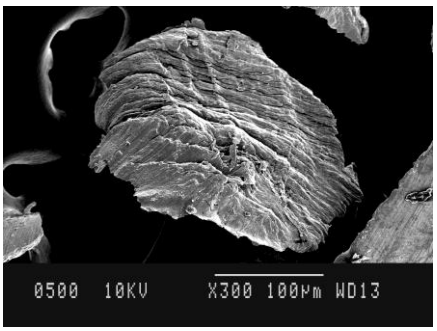
The morphology of the fabricated Zn metal powders was analyzed using SEM images. Fig 3(a), 3(b) and 3(c) shows the SEM images of the fabricated Zn metal powders. It is clear from the SEM images that the powders formed are of relatively uniform shape and size.



3(a)



3(b)



3(c)

Fig3: SEM images of the fabricated Zn metal powders

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IV. CONCLUSION

A low-cost argon gas rotary electrode arc atomization setup has been fabricated and utilized for production of Zn metal powder. Zinc powders were successfully manufactured on developed rotating electrode arc atomization setup at argon environment. The EDS analysis showed that the oxidation of the powders is effectively redistricted by the use of argon gas atmosphere. From the SEM images, it is clear that the powders manufactured are almost in uniform shape. The fabricated powders are can to be used in the fabrication of bio medical implant devices via powder metallurgy and additive manufacturing techniques.

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