1. Introduction

The density of Mg is 1.74 g/cm when compared to Al it is 35.6% lower. Because of its low density Mg based materials find their applications in automobile, aerospace and biomedical industries\(^1\). In recent years, there has been growing interest in magnesium alloys as a new generation of biodegradable materials\(^2\). Biodegradable magnesium and its alloys are advantageous over existing biodegradable materials such as polymers, ceramics and bioactive glasses in load-bearing applications where sufficient strength and Young's modulus close to that of the bone are required\(^3\).

However, fast degradation of magnesium due to corrosion in the human bio environment may limit its clinical applications\(^4\), for example, orthopedic applications, because a too high degradation rate leads to premature deterioration of bio functionality. Alloing is a general approach to improving the corrosion resistance of magnesium as well as its mechanical properties. It is however restricted in the case of designing magnesium alloys for biomedical applications, when the toxicity of alloying elements is taken into consideration. Most of the magnesium alloys that have so far been investigated as potential implant materials are rather complex in alloy composition and contain potentially toxic alloying elements\(^5,6\). Aluminum-containing magnesium alloys, for example, are not preferred material choices for biomedical applications, because accumulation of aluminum is associated with various neurological disorders\(^6\). Previous in vivo Studies\(^7\)–\(^12\) have shown that magnesium-calcium (Mg-Ca) alloys may be suitable as degradable biomaterial for use in medical implant. The close Young's modulus between magnesium (40 GPa) and cancellous bones (Young's modulus 10-30 GPa) has the potential to minimize stress shielding. Furthermore, magnesium, an essential element of the human organism, is biocompatible with the human body. However, the
Achilles heel of a Mg-Ca implant is that it corrodes too fast in saline media such as in the environment of the human organism.

The aim of this work is to fabricate Mg composite by PM and study hardness property for biomedical application such as bone plate.

2. Experiment Procedure

2.1 Materials

| Element composition of Mg Composites | Zn | Zr | Mg | Reinforce Material |
|-------------------------------------|----|----|----|--------------------|
| Elements                            |    |    |    | Ca₃(PO₄)₂          |
| Wt.%                                | 3  | 0.6| Bal.| 2-10               |

2.2 Blending

The materials are added at certain weight percentage as mentioned in Table 1, which is enclosed in an air tight chamber held eccentric in an automatic lathe setup, because of eccentric rotation of the chamber complete blending happens without affecting the rheological phenomenon of the powders. The chamber is allowed to rotate in clockwise and counter clockwise in an hour to ensure optimum blending of powders happens inside the chamber.

2.3 Compaction

Blended powder of 100 grams is loaded in the compaction chamber. Magnesium being the main ingredient acts as the integral binding material holds the ingredients together to make it as a unique billet after applying a pressure of 2 kN/cm², the pressure is applied gradually using hydraulic pressing machine to get the specimen as per the standards as shown in Figure 1. Five Samples are prepared in different Wt.% of reinforced material (2,4,6,8,10) as shown in Table 1 by Powder metallurgy route.

2.4 Sintering

The compacted billet is placed in a muffle furnace having automatic relay to maintain the temperature is used for sintering the billet as shown in Figure 2. Argon inert gases allowed to flow through the chamber of muffle furnace in order to prevent oxidation. The temperature is gradually increased to maintain a range of 450°C for about one hour to ensure better recrystallization of atomic bonding between the ingredients of Mg, Zn, Zr, Ca₃(PO₄)₂ billet.

The billet is allowed to cool within side the hot chamber after turning off the relay supply. The cooled specimen is allowed to get polish using turn table apparatus.

2.5 Hardness Test

Hardness is measured using computer drafting software enabled micro hardness test kit. The specimen is loaded in the work table of the micro hardness test kit. A load of 500 grams is applied for a time span of 10 seconds and Vickers indenter is used for this study. The formed indentation on the specimen is viewed through optical probe, where drafting pointer is used for measuring the diagonal value of the formed indentation. The data captured signal of the drafting pointer is converted into binary value by using the controller unit of the kit. The output hardness value can be read out through the digital display of the unit.

Similarly tests are carried out at three different locations of the specimen, the mean value of the hardness is considered to be the Vickers hardness number for the specimen.
3. Results and Discussion

The table 2 shows the micro hardness value of three trials at three locations and their average hardness value of five different wt% of mg composite samples.

![Vickers hardness testing Machine](image)

**Figure 3.** Vickers hardness testing Machine.

![Graphical representation of hardness value](image)

**Figure 4.** Graphical representation of hardness value.

| SPECIMEN | MICRO HARDNESS VALUE (HV) | MICRO HARDNESS AVERAGE (HV) |
|----------|---------------------------|----------------------------|
| Trial 1  | Trial 2 | Trial 3 | |
| 1        | 53.77  | 58.05  | 56.36 | 56.06 |
| 2        | 94.42  | 83.57  | 90.36 | 89.36 |
| 3        | 93.45  | 92.64  | 90.87 | 92.25 |
| 4        | 110.2  | 107.0  | 109.2 | 108.8 |
| 5        | 81.91  | 86.79  | 83.6  | 84.1  |

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![Graphical representation of hardness value](image)

**Figure 4.** Graphical representation of hardness value.

Sample1 -2wt%, Sample2 -4wt%, Sample3- 6wt%, Sample4 -8wt%, Sample5 - 10wt%.

The Figure 4 represents the micro hardness value of five different wt% of mg composite. From the Figure, it is noticed that increase of reinforcement (CAP) from 2wt% to 8wt%, the hardness value is improved from 50HV to 108.8HV, and further addition of CAP to 10wt% reduces the hardness value to 84.1HV, this is because of the weak bonding between the molecules of alloying element leads to deterioration of the hardness of the material.

4. Conclusion

Hardness test carried out for the various compositions of magnesium composites and the result shows a gradual increase in hardness is identified by gradual increase in the amount of calcium phosphate reinforcement material. The values show that the hardness will be maximum at 92 wt% ZK30 and 8 wt% of Ca₃(PO₄)₂, and reduces the hardness rapidly above 8wt% of CAP.

5. References

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