# Different Compositions of Bismuth-Lead Binary Alloy and their Mechanical Properties

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***Abstract*-** In the present work, the different composition of Bismuth-lead binary alloys are grown by Zone- Refining Technique under a vacuum atmosphere on the basis of percentage of molecular weight 9:1, 5:5 and 1:9 ratios. The EDAX of these samples are done and the results are reported. The effect of temperature and load on the hardness of the grown alloy has been studied. Further the comparative studies of work hardening coefficients are reported.

***Index Terms*-** EDAX, hardening coefficient, Micro hardness, Bi-Pb alloy, mechanical properties, Work hardening coefficient

## I. Introduction

An alloy is a substance that has metallic properties and is composed of two or more chemical elements, of which at least one is metal. Authors have grown Bismuth-lead alloys by Zone- Refining Technique on the basis of percentage of molecular weight 9:1, 5:5 and 1:9 ratios. Zone refining is only one of a class of techniques known as zone melting in which a molten zone is passed down a solid rod. Zone melting is used routinely to collect impurities in high purity materials. Energy dispersive X-ray spectroscopy an analytical technique used for the elemental analysis or chemical characterization of a sample. There for the EDAX of the grown alloys are carried out. The results of EDAX are discussed in the result. For classifying materials, hardness test are performed more frequently than any other mechanical tests. In the present work, the micro hardness of the grown alloys are measured by Vaiseshika Vicker's micro hardness tester. Vickers Hardness is a measure of the hardness of a material, calculated from the size of an impression produced under load by a pyramid shaped diamond indenter. The work hardening coefficient (n) of the material is related to the load (p) by the relation $P=ad^n$ , Where 'a' is an arbitrary constant. The work hardening coefficients of the grown alloys are investigated.

## II. Materials and Methods

The materials used for the present work are Bismuth and lead. Bismuth has a high electrical resistance, and has the highest Hall Effect of any metal. Bismuth rich alloys (>50 wt %) have the unique feature that they expand on solidification(Mustafa Kamal *et al.,* 2004).When Bismuth is alloyed with other metals such as lead, tin or cadmium, it forms low-melting alloys, which are extensively used for safety devices in fire detection and extinguishing systems(Rizk Mostafa Shalaby *et al.*,2009; Mustafa Kamal *et al.*,2005 ).

Lead and its alloys can be fabricated by almost all commercial processes. It can, for instance, be extruded, drawn, rolled, cast, stamped, and spun and can be applied as a coating to other metals. Thick layers of lead can be bonded to steel or other metals to form lead claddings.

Bi-Pb alloy was prepared on the basis of percentage of molecular weight 9:1, 5:5 and 1:9 ratio. These samples were carefully melted in the oxidation furnace and shaken well in zone tube. These samples are successfully grown by Zone- Refining Technique under a vacuum atmosphere (~ 4 x $10^{-2}$ mbar). The metals were melted together in a quartz tube which is 1.5 meter long and 2 cm diameter. The Electric motor which has very low rpm and having speed of 1.5 cm/hr, 1 cm/hr, 0.5 cm/hr and 0.25 cm/hr connected to the heating coil with very low friction trolley. The one end of the trolley is connected to the motor and the other end of this trolley is connected to the load. A series of molten zone passes in uniform one direction and also set the temperature up to melting temperature inside the tube. Apparatus of Zone - Refining Technique is shown in Fig.1. Samples grown by zone refining techniques are shown in Fig. 2.

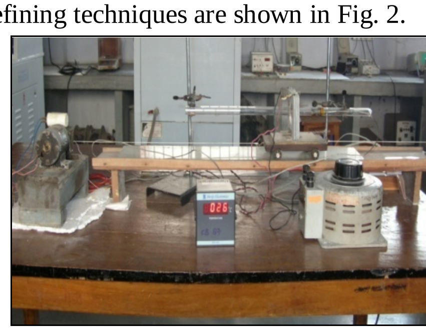

Figure 1 Zone - Refining Apparatus


Figure 2 Bi-Pb alloy

EDAX is a qualitative analysis and conformation test of mixture of two metals. The EDAX of the grown alloys are investigated as shown in figure-3 and discussed in the result.

To study the effect of temperature on the hardnesses of grown alloys the heating coil is used. The line diagram of the coil is 0.5 cm with 6 cm in length. In order to determine the effect of temperature on the micro-hardness of the grown alloys, they were carried out from temperature 303 K at an interval of 5 K by keeping the load of 0.020 kg, loading time of 10 seconds (Pandya G.R *et al.,* 2000). The graph of Hardness vs. temperature are plotted as shown in Figure-3.Then the effect of different loads from 0.005 kg at the

ISSN 2250-3153

interval of 0.005 kg by keeping constant temperature and loading time of 10 seconds is studied (Adiyodi, A.K. *et al.*, 2009; Shah N. *et al.*,2007)The graphs of Hardness Vs Load are plotted as shown in figure-4.

The work hardening coefficient (n) of the material is Related to the load (p) by the relation

$$P=ad^n \qquad (1)$$

Where 'a' is an arbitrary constant. From (1)

$$\log p=\log a+n \log d \qquad (2)$$

By comparing (2) with

$$y=mx+c, \qquad (3)$$

Where, y=log p, x=log d and m=n=slop of the graph which represents the work hardening coefficient. (Ambujam K. *et al.*, 2006; Ushashree P.M. *et al.*,2002; Pricilla Jeyakumari *et al.*,2004). So from graphs of log p Vs log d, the work hardening coefficients and the graphs are discussed in the result part and

## III. RESULT

Energy dispersive X-ray spectroscopy of the grown alloys is shown in Figure 3. Data are shown in Table 1.

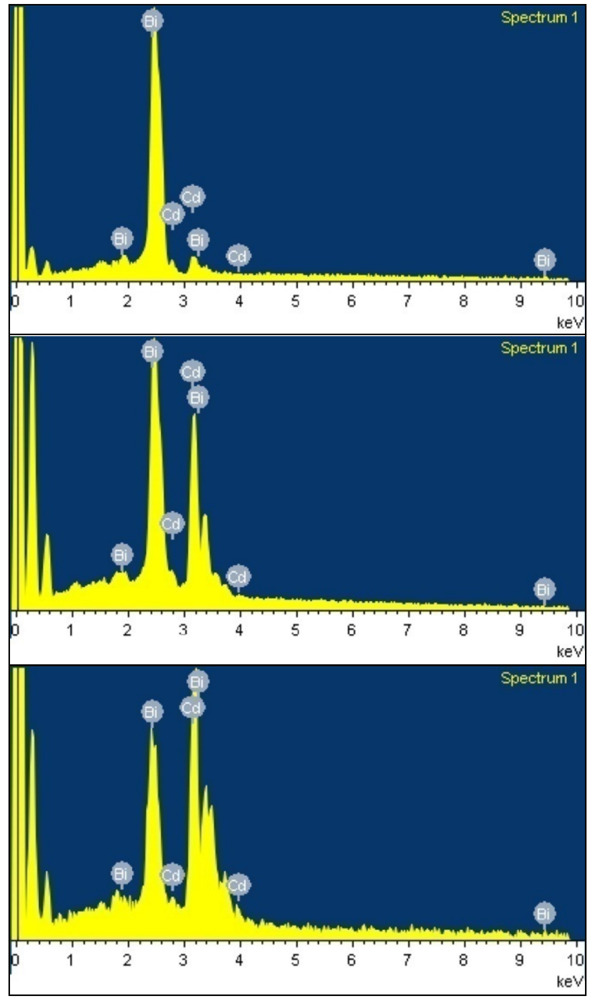


Figure 3 (a) EDAX for Bi-Pb (9:1) (b) EDAX for Bi-Pb (5:5)
(c) EDAX for Bi-Pb (1:9)

Table 1: Data from EDAX for the grown alloys

| Bi-Pb Composition | | | | | |
|---|---|---|---|---|---|
| 9:1 | | 5:5 | | 1:9 | |
| Weight % | Atomic % | Weight % | Atomic % | Weight % | Atomic % |
| 77.54-22.46 | 77.39-22.61 | 93.68-6.32 | 93.63-6.37 | 20.07-79.93 | 19.93-80.24 |

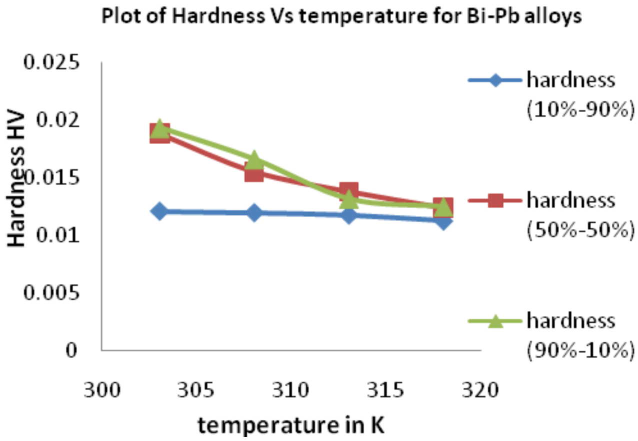


Figure 4 Graphs of Hardness vs. Temperature

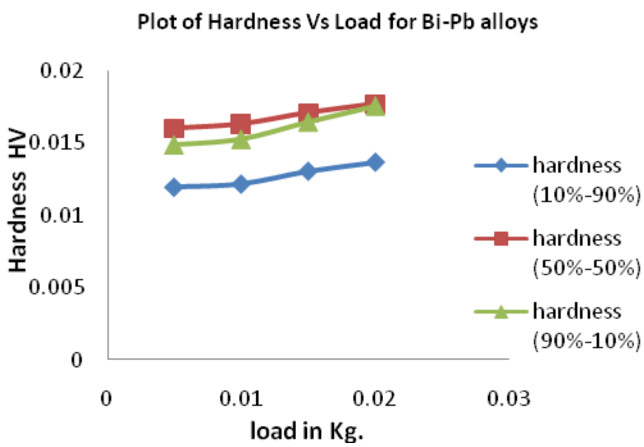


Figure 5 Graphs of Hardness vs. Load

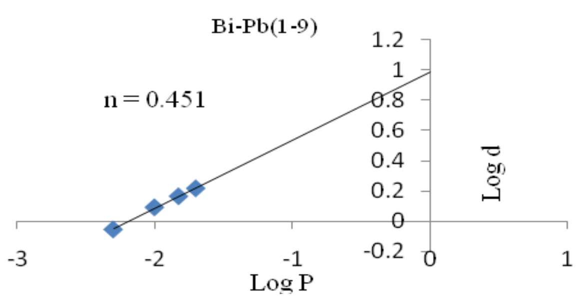


Figure 6 Plot of Log d vs. Log p for (1:9) Bi-Pb

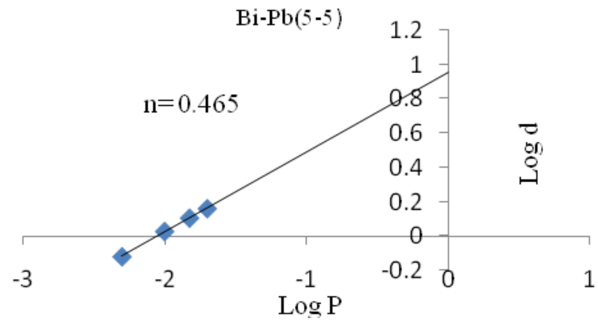


Figure 7 Plot of Log d vs. Log p for (5:5) Bi-Pb

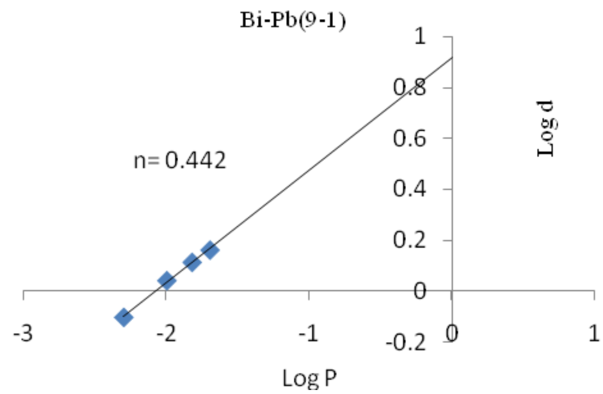


Fig. 8 Plot of Log d vs. Log p for (9:1) Bi-Pb

## IV. CONCLUSION

The work hardening coefficient of 5:5 Bi-Pb alloy is 0.465 which if approx 0.5. The work hardening exponent (n) is known to be a good indicator for the work formability of materials. A material with a higher 'n' value is preferred for manufacturing processes which involve plastic deformation (M.R. Akbarpour *et al.*, 2008).

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