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Effect of Varying Lead Percentage on Mechanical Properties of Gun Metal

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Abstract - Gun metal also known as red brass is an alloy of copper, tin, zinc and lead. Literature describes pure gun metal as an alloy of copper (85%), tin (5%), zinc (5%) and lead (5%). An attempt is made to vary the percentage of lead in the gun metal alloy and investigate the resulting micro-structure and mechanical properties. The new alloy exhibits good vickers hardness and ultimate tensile strength. Hence, there is good scope of using this new alloy alloy in wear resistant applications.

Keywords*- Gun metal; Lead; Mechanical Properties; Tensile Strength; Microstucure*

I. INTRODUCTION

Gun metal also known as red brass is a type of bronze, an alloy of copper, tin, zinc and lead. It was originally used for making guns. Gun metal casts and machines well, it is also resistant to corrosion from steam and is used to make steam and hydraulic castings and valves. Gun metal is also used to make gears and bearings that are subjected to moderate speeds and loads. The existing literature describes pure gun metal as an alloy of copper (85%), tin (5%), zinc (5%) and lead (5%). In the project reported in this paper we varied the percentage of lead in the gun metal alloy and studied the micro-structure and mechanical properties of the new alloys made by varying the lead percentage. Moreover copper is more costly as compared to lead, hence the cost of gun-metal can be reduced by lowering the percentage of copper in the alloy.

II. SAMPLE PREPARATION

The samples had been prepared at M/s Aadhya Engineering, Vadodara-10. The three samples with varying lead percentage have been cast using sand moulding technique. The steps followed are as follows:

1. Place pattern in sand and create a mold cavity.
2. Prepare the gating system.
3. Remove the pattern.
4. Fill the mold cavity with molten gun metal and vary the percentage of lead for each sample been cast.
5. Allow the metal to cool.
6. Break away the sand mold and remove the cast samples .
7. Prepare samples by machining for tests according to ASTM standards.
8. Polish the machined samples using coarse and fine sand paper.

III. TESTING SAMPLES

3.1 The Chemical Analysis of the samples is done using optical emission spectrometer and the results obtained are as given in Table- 1.

Table 1. Chemical analysis of samples

	Sample 1	Sample 2	Sample 3
Zinc %	3.4	3.15	3.18
Lead %	7.270	11.57	16.98
Tin %	6.720	6.420	7.290
Copper %	81.50	77.20	71.30

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3.2 The microstructure of the prepared samples is studied using optical microscope TCR-ADV/E-20 at 100X and 500X. The samples are prepared using potassium dichromate as etchant.

3.2.1 Sample-1 (with 7.270 % lead)

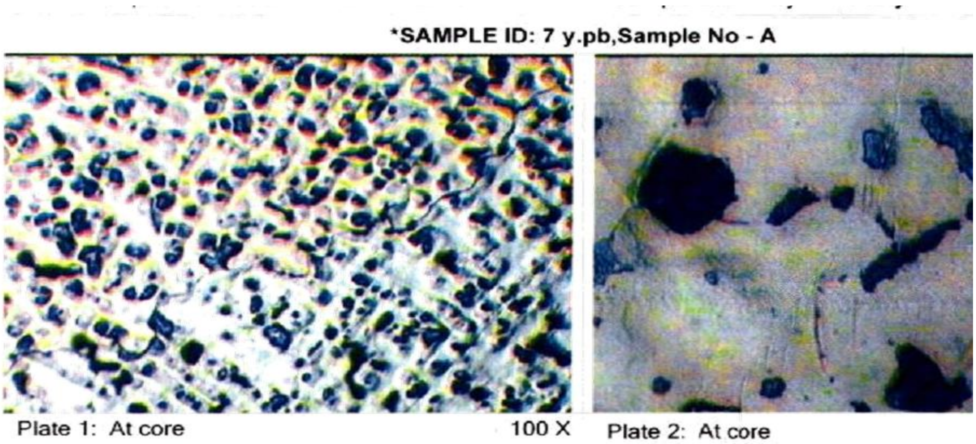

Figure 1. Microstructure of sample 1

The microstructure of sample-1 (Figure-1) shows inter dendritic tin rich delta phase in the matrix of copper rich alpha phase. The lead particles (black) are observed in microstructure.

3.2.2 Sample-2 (with 11.570 % lead)

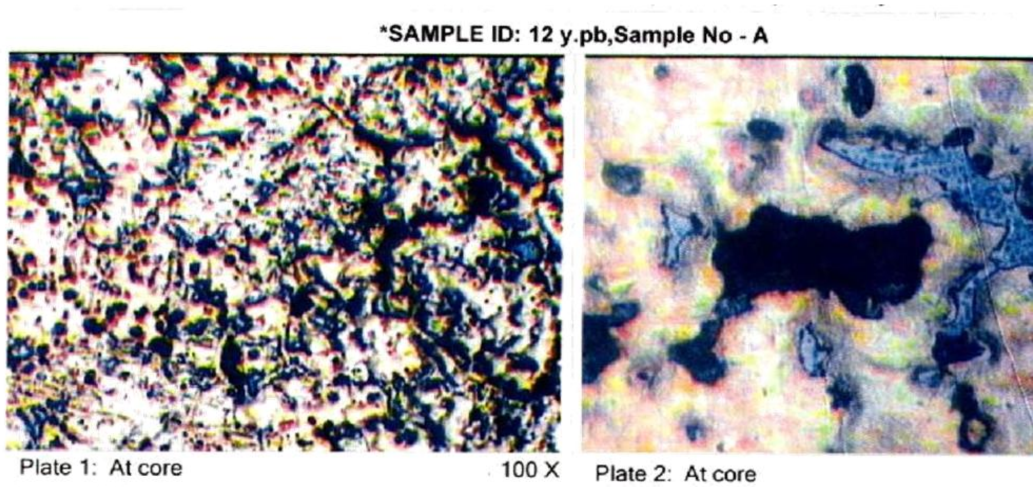

Figure 2. Microstructure of sample 2

The microstructure of sample-2 (Figure-2) shows inter dendritic tin rich delta phase in the matrix of copper rich alpha phase. The lead particles (black) are observed in microstructure.

3.2.3 Sample-3 (with 16.980 % lead)

The microstructure of sample-3 (Figure-3) shows inter dendritic tin rich delta phase in the matrix of copper rich alpha phase. The lead particles (black) are observed in microstructure.

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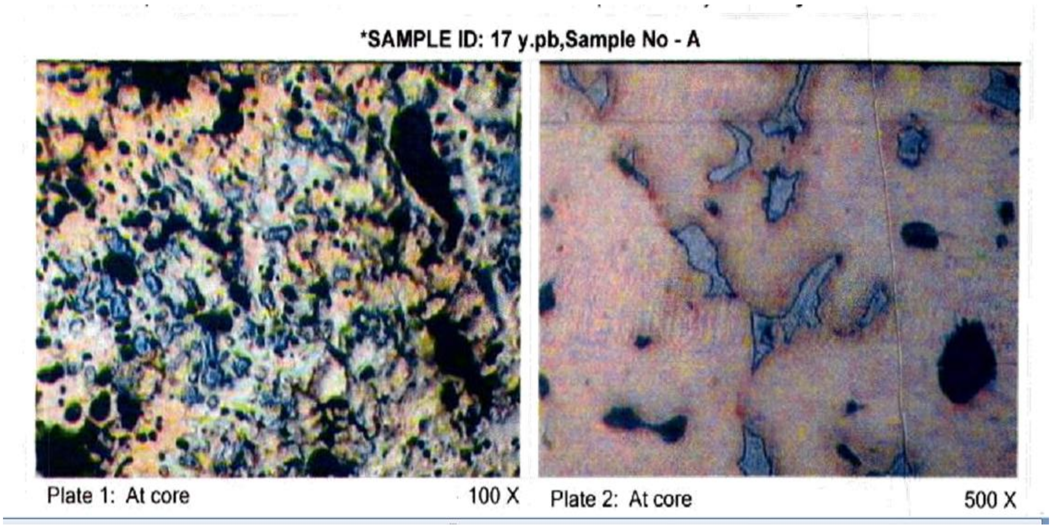

Figure 3. Microstructure of sample 3

IV. ANALYSIS OF MECHANICAL PROPERTIES

4.1 Tensile Test - It is a fundamental material science test in which a sample is subjected to a controlled tension until failure. The results from this test are commonly used to select a material for an application, for quality control and to predict how the material will react under other types of forces. Properties that are directly measured using tensile test are ultimate tensile strength, maximum elongation and reduction in the area. The instrument used to conduct the test was Al-UTM-40T and the results obtained are shown in Table-2.

Table 2. Results of tensile test

Parameter	Unit	Sample 1	Sample 2	Sample 3
Gauge Diameter	mm	12.62	12.60	12.55
Area	mm^2	125.08	124.69	123.7
Gauge length	mm	50.00	50.00	50.0
Final length	mm	53.09	51.74	51.66
0.2% proof load	N	14323	13621	13815
Ultimate load	N	19760	15400	17760
0.2% proof stress	N/mm^2	115	109	112
UTS	N/mm^2	153.25	132	123
% elongation		6.18	3.48	3.32

4.2 Hardness Test - The Vickers hardness test is used as its calculations are independent of the size of the indenter. The basic principle is to observe the materials ability to resist plastic deformation from standard source. The unit of hardness given by Vickers hardness test is known as Vickers Pyramid Number (HV). The result obtained HV10 is shown in Table-3.

Table 3. Results of Vickers Hardness Test

Parameter	Sample1	Sample2	Sample3
HV10	137.0	137.0	123.0

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V. RESULT AND DISCUSSION

Figure 4. compares the ultimate tensile strength of standard specimen with new samples. Figure 5 compares Vickers hardness of standard specimen with new samples. The sample-2 indicates ultimate tensile strength as 132N/mm^2 , as compared to ultimate tensile strength of available gun metal as 152N/mm^2 and Vickers hardness for sample-2 HV10 as 137.0 as compared to Vickers hardness of standard gun metal as 75 HV10.

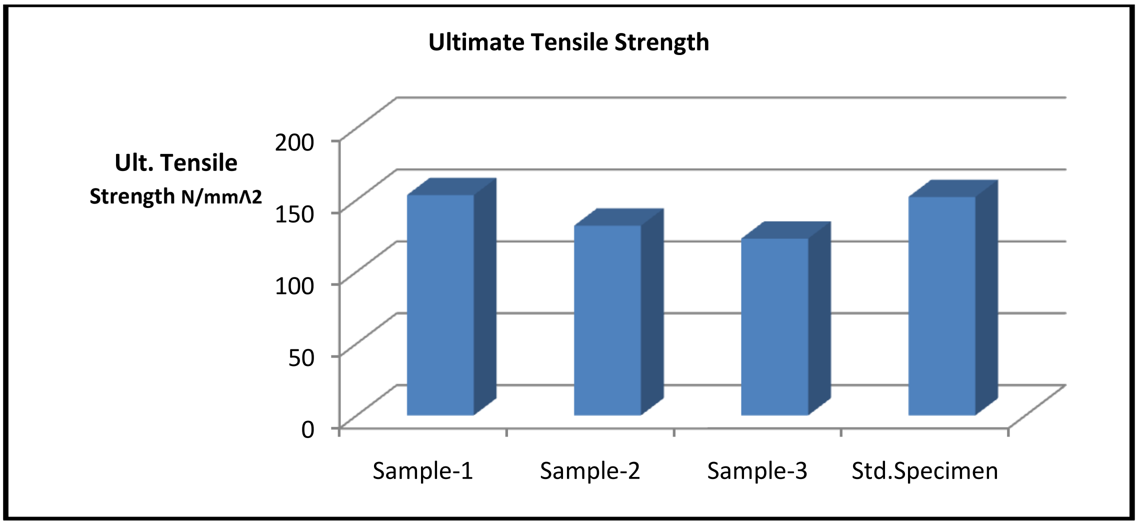

Figure 4. Comparison of Ultimate Tensile Strength of Standard Specimen with samples

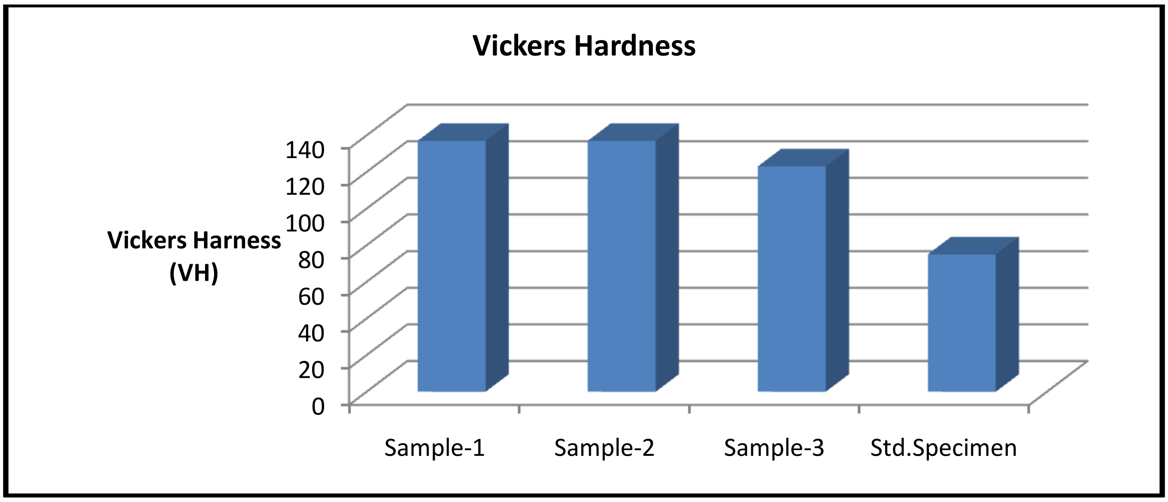

Figure 5. Comparison of Vickershardness of Standard Specimen with samples

VI. CONCLUSION

It can be inferred from the above study that sample-2 with chemical composition 77.2% copper, 3.15% zinc, 6.420% tin and 11.570% lead has better mechanical properties as compared to standard gun metal. The Vickers hardness (HV10) of sample-2 is 137 HV as compared to 75 HV of standard gun metal. The ultimate tensile strength of sample-2 is 132 N/mm^2 and that of the standard specimen is 152N/ mm^2.As the hardness obtained for sample-2 is better it would further increase wear resistance and make it more suitable for wear resistant applications like bushes and bearings. Moreover, as the percentage of copper has been reduced in the new alloy material, the cost of the final product would also be lesser as compared to that manufactured using the available gun metal, which would definitely be of interest to application engineers.

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