International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Mechanical Properties of High Entropy Alloy (AlCuFeMnZn) Prepared by Casting

Umang Singh[1], Dr. Satpal Sharma[2]

[1, 2]Gautam Buddha University, Noida, Uttar Pradesh, India

Abstract: ***HEAs are multicomponent and have high entropy configuration. In this work, experimental analysis of mechanical properties of alloy (AlCuFeMnZn) has been studied. Various mechanical tests – hardness test, tensile test, strength elongation, yield strength and spectrograph carried out. On performing the tests we can conclude that the alloy have averagely high tensile strength, yield strength, ductile strength and hardness. While comparing the initial compositions of this alloy, we find out that final compositions were change (altered during the casting process) that decide the physical and chemical properties of this material.***

Keywords: High Entropy Alloys, Rockwell Hardness Test, Universal Testing Machine, Mechanical Properties.

1. Introduction

HEAs (High Entropy Alloys), basically the mixing of five or more elements to form a large relatively material. Alloying the base material with different material, not only reinforce the material but also affect the very nature of the material. The HEAs are also known as Novel Materials. The entropy as well as mechanical properties vary as per the content of elements.

In the work alloy of Aluminum(Al), Copper(Cu), Iron(Fe), Manganese(Mn) and Zinc(Zn) has been casted in 2000 c conventional furnace using sand casting by weight ratio system.

Rockwell hardness test, Spectrograph, yield strength, ductile strength, and tensile strength tests have been performed by using three sample of length 10-11cm and 3cm diameter workpiece of alloy.

2. Material Selection

The concept of high entropy alloys (HEA)s has ignited renewed interest in fundamental thermodynamics, processing, and characterization approaches for multicomponent alloys. HEAs has covered a significant space of characterization and processing approaches, therefore cheap and easily available materials have selected. The following materials have been selected to make alloy by equal weight percentage.

Aluminum (Al), Copper (Cu), Iron (Fe), Manganese (Mn) and Zinc (Zn).

Table 1: Selected Materials

S.No	Material Name	Melting Point©	Boiling Point	Function
1	Fe	1538	2862	High Strength
2	Cu	1085	2562	High ductility
3	Zn	450	1000	Corrosion protection
4	Mn	1240	2060	Flexibility, ductility
5	Al	660	2470	Engineering feature

On approaching through numerical method, the minimum requirement for making the high entropy alloy are ΔS_{mix} should be maximum, ΔH_{mix} should be lie between the -10 to -5 KJ/mol, difference in atomic radius must be at most 6.6%. The material used to make alloys have ΔS_{mix} = 32.57 KJ/mol and difference in atomic radius "δ" = 4.26%. Through above values we can manufacture the high entropy alloy.

2.1 Casting Alloy

With the help of conventional furnace and sand casting with temperature touched 2000°C.After cooling the workpiece so obtained of size 10-11cm in length and 2.75-3 cm in diameter.

Figure 1: Woks piece after Casting

3. Mechanical Testing

Mechanical properties are Intransitive properties of the material. These quantitative properties used in benefits of the material with respect to another material in material selection process. In other words mechanical properties of engineering materials describes of the material under action of external force.

3.1 Rockwell hardness

The hardness of the material are tested on the Rockwell hardness testing machine with the 150 KN of load categories in B type hardness number. Two indentation were applied to test the material, first is used to make indentation position and other is used with increased load upto 150 KN.

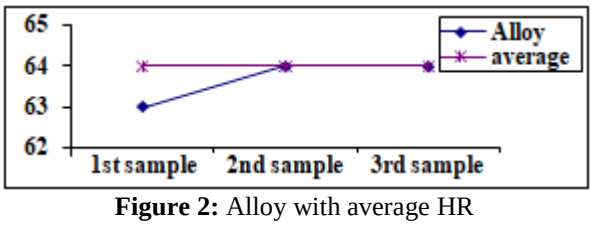

Figure 2: Alloy with average HR

Table 2: Hardness Number

S.no	Elements	Hardness
1	Fe	49
2	Cu	3
3	Mn	75
4	Zn	14
5	Al	30
6	AlCuFeMnZn	64

3.2 Tensile Strength

The Tensile of the material is to bear maximum stress just before the failure. The tensile strength on performing the test in universal testing machine provide 362.13 N/mm^2 under the maximum testing load of 100 KN.

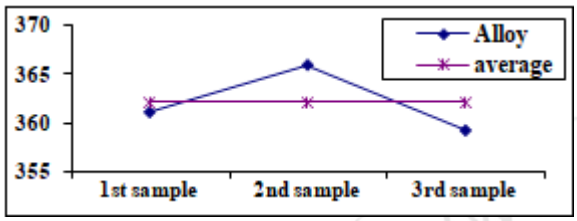

Figure 3: Tensile with average

Table 3: Tensile Strength

S.no	Elements	Tensile strength
1	Fe	414
2	Cu	200
3	Mn	389
4	Zn	28
5	Al	310
6	AlCuFeMnZn	362.13

3.3 Yield Strength

Yield strength is that strength at which a specific amount of plastic deformation is produces in the material. The yield strength of the material is 232.16 N/mm^2 under 0.2 % proof stress.

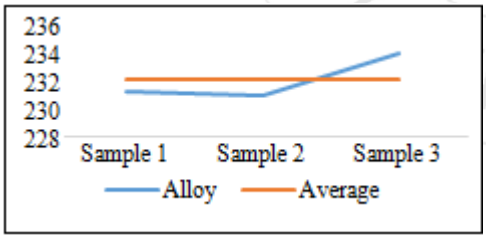

Figure 4: Yield with average

Table 4: Yield Strength

S.No	Materials	Yield Strength
1	Fe	50
2	Cu	69
3	Mn	201
4	Al	276
5	AlCuFeMnZn	232.16

3.4 Ductile Strength

The Ductility of the material pictures the tendency to undergo plastic deformation before breakdown. The elongation % of the material is 21.2% using the UTM.

3.5 Spectrum Analysis

Spectrophotometry is a tool/method by which quantitative analysis of material that are present in the material which is to be tested using optical arrangements. It can find all most every material in the periodic table. The analysis is base on the weight by weight percentage. The initial ratio of 1:1:1:1:1 is used by weight (20% every element composition).

Table 4: Spectrophotometric Analysis

S.no	Elements	After
1	Fe	18.058
2	Cu	22.670
3	Mn	21.668
4	Zn	18.154
5	Al	18.001

4. Equations

$$\Delta S\ mix = -nR\{X_1\ In\ X_1 + X_2\ In\ X_2\} \quad (1)$$

$$\delta = \sqrt{\{\sum_{i=1}^{n} ci\left(1 - \frac{ri}{r*}\right)\}} \quad (2)$$

5. Conclusion

The formation of the High entropy alloys is conducted using only two minimum requirement criteria which is entropy of mixing (ΔS_{mix}) should be maximum and the difference of atomic radius (δ) should be in less than 6.6%. The material (Alloy) show averagely high yield strength, tensile strength, hardness and elongation. Some properties have more and less properties on comparing with individual elements due to presence of errors and inadequate amount of element during casting or may be occur during uncontrolled cooling of the material (Defected arises during the casting or impurities presence in the powder form elements)

References

[1] Material selection considerations for high entropy alloys by X.Fu, C.A.Schuh on department of material science and engineering.
[2] High temperature wear in CoCrFeNiCu high entropy alloy: the role of copper by A. Verma, P. Tarate on department of metallurigical and material engg.
[3] Mechanical properties of high-entropy alloys with emphasis on face-centered cubic alloys byZezhou Li, Shiteng Zhao, Robert O. Ritchie, Marc A. Meyers.

Author Profile

Umang Singh currently pressuring B.Tech. + M.Tech. Integrated dual degree from Gautam Buddha University, Greater Noida, India.