

Comparative Studies of the Fluidity of Some Selected Non-Ferrous Metals and Alloys

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Abstract
Selection of the types of non ferrous metal and alloy for casting into the desired products has been based on the characteristic of the metal and alloy. If a sound casting is to be achieved, so that the desired product will not have defect or fail in service, fluidity of the non ferrous metal or alloy should also be considered in selection. So this research work carried out comparative studies of fluidity of Aluminium, Brass and Bronze. The results showed that bronze has the highest fluidity of 56.5cm at its maximum pouring temperature of 1288^{o}C and aluminium has the lowest fluidity of 34.6cm at its minimum pouring temperature of 650^{o}C
Keywords: Fluidity, non-ferrous metal , alloy, casting, aluminium, brass, bronze .

1 Introduction

Non-ferrous metals and their alloys are used in industry to produce ornaments, utensils, electric cables machine components e.t.c, because they are easy to form by casting, rolling, forging and machining. They also have high resistance to corrosion, very good electrical and thermal conductivity, low density and attractive appearance (Khurmi & Gupta, 2006)

Casting of these non-ferrous metals such as Lead, Zinc, Aluminium e.t.c and their alloys Brass and Bronze has been one of the primary shaping processes used in the manufacturing of the aforementioned products. Prior to casting, they are melted in furnaces. After melting and reaching their pouring temperatures, they are poured into a mould to cast the desired product.

Since all non-ferrous metals have the same characteristics as earlier stated, choosing a metal for a sound casting, fluidity is a basic factor for consideration (Srivastava, 2003), (Ndaliman et al, 2011)

Fluidity has come to a meaning quite different to the foundry man than to the physicist. To the physicist, it is the reciprocal of viscosity (Cooksey, 1959) cited by Khan et al (2008). To the foundary man, as well as in foundary science, fluidity is the ability of molten metal to flow before stopped by solidification (Flemings, 1974) cited by (Disabatino and Arnberg 2011)

In general, fluidity is a measure of the ability of a metal or alloy to flow and fill a mould and give a good casting of its inner surface.

Fluidity is influenced by the compositions, superheat, latent heat, surface tension of the melt, including oxide film and mode of solidification which are the metallurgical factors, heat transfer coefficient at interface, mould temperature and mould conductivity which are the mould/casting factors (Flemings, 1974), (Mollard, 1987), (Meier, 1965), (Voigt, 2002).

Fluidity values are generally given as the distance flow of a molten metal or alloy through a channel of a particular cross-section before solidification. This term is usually used in scientific research as a means for comparing various metals or alloys from the point of views of their suitability for casting and is found to be most useful in relation to aerofoil and other thin complicated casting (Srivastava, 2003)

Fluidity tests have been developed and are used commercially as quality checks to determine the flowing qualities of metals (West, 1902) cited by Khan et al (2008).

The aim of this work is to determine and compare the fluidity of Aluminium, Brass and Bronze.

2 Materials and Methods

2.1 *Types and compositions of non-ferrous metals and alloys selected for study.*

(i) Aluminium (Al) --- 99.59 %(Al), 0.03 %(Cu), 0.04 %(Fe) and 0.34(Si)

(ii) Brass --- 81 %(Cu), 10%Zn, 3.5%Sb and 5.5 %(Pb)

(iii) Bronze --- 83 %(Cu), 7 %(Sb), 6.5%Pb and 3.5%(Zn)

2.2 *Experimental Test Rig.*

The Experimental Test Rig used to measure the fluidity of the selected metal and alloys was designed and fabricated. It is similar to that of Ragone(1955) and Dewhrist(2008) but with little modifications. The schematic diagram is shown in figure 1.

The Experimental Test Rig consists of a vacuum pump driven by 0. 5hp electric motor, pyrex glass, vacuum hose , valves, reservoir bottle, vacuum gauge, crucible, metre rule, Type K thermocouple with Digital read out, manufactured by R.K.C. instrument Inc, Japan and electric furnace, manufactured by British ceramic service, co ltd.

2.3 *Experimental*

Procedure.

5kg of each of the selected samples were individually put in the crucible and put in the electric furnace. The furnace was powered to melt the individual metal and alloys. When their pouring temperatures were reached in constant intervals between the minimum and maximum pouring temperatures of the selected non-ferrous metal and alloys, as indicated by Digital read out of the Type K thermocouple, the furnace was switched off. Pressure head of the metal was produced by creating partial vacuum to one end of the tube by vacuum pump. The end which was in the entrance to the tube was dipped into the metal in the crucible; the probe of the thermocouple was also dipped or inserted into the crucible to measure the temperature. The molten metal and alloy was drawn by a vacuum into the tube and the distance it travels and the time taken before solidification, were measured with a meter rule and stop watch respectively. SO_2 was used to clean the tubes and the entire system after each experiment. The experiment on each metal and alloy was conducted four times and the average readings and measurements were taken and depicted in Tables 1, 2 and 3

3 Results and Discussion

It can be seen from Tables 1 to 3 that, the fluidity of the various metal and alloys increased as the pouring temperature increased.

The fluidity of Bronze were found to be higher than that of Aluminium and Brass. Aluminium was found to have the least fluidity. This is evident in Tables 1, 2 and 3.The high values of the fluidity of Bronze could be attributed to the presence of higher percentage of Tin as Tin increases fluidity, strength,hardness and corrosion resistance of Bronze(www.differencebetween.com) .However, the fluidity of Aluminium was found to be higher than that of lead and zinc which were found to be 32.5cm and 25.8cm at 25°C superheat respectively by Srivastava(2003). This increase in fluidity compare to that of lead and zinc could be attributed to the presence of silicon in the Aluminium ingot which improves the fluidity of the molten metal as well as its castability (Abdulwahab ,2008)

It can also be seen from Tables 1, 2 and 3 that the time taken by the various metal and alloy to attain their fluidities increased as the pouring temperatures of the molten metal and alloy increased.

4 Conclusion

From the results of the test, it is very evident that Bronze has the highest fluidity in comparing with others. If casting of intricate parts are desirable, as fluidity has a major role to play, Bronze should be given a consideration though it is more expensive than others. Fluidity test can help to establish the quality of metal or alloy, before parts or component are badly cast.

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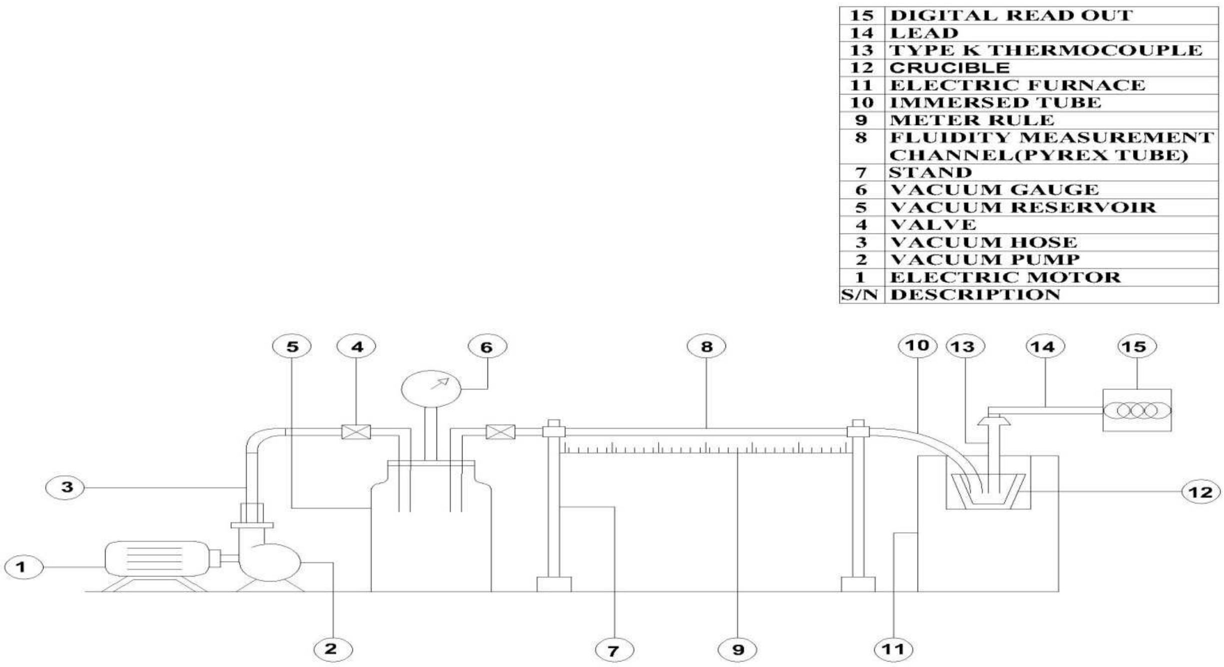

Figure 1 Experimental Test Rig

Table 1. Fluidity of Aluminium at different pouring temperature and time

Pouring temperature (°C)	Fluidity (cm)	Time (s)
650.0	34.6	57

675.0	36.1	71
700.0	37.8	95
725.0	39.2	112
750.0	40.7	122

Table 2. Fluidity of Brass at different pouring temperature and time

Pouring temperature (^oC)	Fluidity (cm)	Time (s)
1066.0	45.3	61
1114.5	48.5	83
1163.0	50.6	121
1211.5	52.2	134
1260.0	54.4	152

Table 3. Fluidity of Bronze at different pouring temperature and time

Pouring temperature (^oC)	Fluidity (cm)	Time (s)
1066.0	47.7	63
1121.5	49.1	89
1177.0	51.2	128
1232.5	52.8	140
1288.0	56.5	161