PROPERTIES OF ZINC ALLOY CAST PRODUCT WITH DIFFERENT COMPOSITION OF SILICA SAND AND BENTONITE IN GREEN SAND MOULD

Zatil Alyani Mohd Amin, Faizul Che Pa, P.M Ir. Mohd Ichwan Nasution

School of Material Engineering,
Kompleks Pusat Pengajian Jejawi 2,
Universiti Malaysia Perlis,
02600, Jejawi, Perlis, Malaysia

Email: alyani_amin@yahoo.com

ABSTRACT

This project is to produce tertiary alloy of Zinc-Aluminium-Magnesium (Zn-3Al-2Mg) with different composition of bentonite and silica sand in the green sand mould. Zn alloy casting industry using green sand molding is increasingly becoming to very competitive circumstance, due to the various casting methods such as die cast, sand mould and so on with the recent coming of the lightening demand in automotive and decorative industry. However, Zn alloy casting using green sand still now plays an important role in the foundry society, because it allows us to manufacture at low cost and also sand can be recycled. Furthermore, it is appropriate method for multi kind and small quantity production. The mentioned method of mold is differing in composition of bentonite with 5%-17%. Differ in the composition of bentonite and silica sand give differ in result. The properties are obtains from the surface, the hardness test, the tensile test and the microstructure. Lowest and highest percentage of bentonite gives a dull surface properties compare to the in between. The shiniest surface is from the 15% of bentonite. Meanwhile, for the hardness test and the tensile strength, the results show the same with the surface properties. The morphologies give not much difference from each other.

Keywords*: green sand mould, zinc alloy, silica sand*

INTRODUCTION

Molding sands used by the metal casting industry are produced by mixing virgin silica sand with clay or organic chemical binders. The most widely used sand binders are bentonite clays (sodium bentonite and calcium bentonite), and these molding sands are known as green sands (Robert et al., 2007). Green sand molding is one of many methods available for making a mold which molten metal can be poured. The term green sand is uses to denote the presence of moisture in the mould mixture when molten metal is poured into the mould just as green wood still contains its moisture (Luther, 1997-1998). Green sand is prepared by coating the grains of sand with a clay-water mixture that's binds the sand into rigid mass by the application of force. Greensand is foundry sand that's uses clay-water bonding thus enabling moulds to be produced at high production rates by simple squeezing and compaction. The main advantage of clay bonded sands is that they can be continually re-used by cooling and then remixing with additions of water, new clay and fresh coal dust, etc. to replace the relatively small amounts lost or destroyed during casting, together with additions of some new sand. The raw materials used are relatively inexpensive and are only completely broken down in the very high thermal loaded parts of the mould that are in contact with molten metal (Kunihiro et al., 2008).

Zinc in its unalloyed form is a bluish-white metal with a density of 7.1 g/cm^3, a melting temperature of 420˚C (788˚F) and a boiling temperature of 906˚C (1663˚F). It is readily cast and crystallizes in a hexagonal closed-packed structure. Zinc has been used traditionally to galvanize steel surface against corrosion. The zinc casting alloys have been developed primarily in North America and are finding increasingly wide application (Yujue, 2006). More magnesium, they become brittle, more machining is made difficult and pressure working becomes impossible. Zinc alloy are stronger than most alloys. It has high wear resistance and bearing properties. But, the problems at the surface sinks and shrinkage defects on the bottom faces.

MATERIALS AND METHODS

GREEN SAND MOULD

Green sand mould consists of bentonite, silicate sand and water. When forming cast iron and gray iron, the green sand mould usually contain silica sand (82-90%), bentonite clay (5-8%), water (1.5-4%). When casting complex shape, core sands can also include organic resins binder eg phenolic urethane (Yujue, 2006). 7 moulds were prepared using 7 different ratios of silicate sand, bentonite and water. The ratio used as above, and the water ratio are the same for each mould.

Table 1: Ratios used for the green sand mould

Sample No.	Ratio	Silica sand (kg)	Bentonite (kg)	Water (kg)
1	95:5	5.70	0.30	0.24
2	93:7	5.58	0.42	0.24
3	91:9	5.46	0.54	0.24
4	89:11	5.34	0.66	0.24
5	87:13	5.22	0.78	0.24
6	85:15	5.10	0.90	0.24
7	83:17	4.98	1.02	0.24

Silica sand used was obtained from Dan Cast Sdn. Bhd. Clay used in green sand foundries is bentonite. Bentonite contains mineral montmorillonite, but it can also include portions of other clay minerals. Bentonite clays have been used as bonding materials in green sand foundries for centuries. Water is an important component of green sand matrix. Responsible for the proper clay activation during sand mulling and therefore the overall strength of the green sand mould. (Smiernow et al., 1980). Specially it is the clay-to-water-to-clay interaction that creates the bridge and surface bonding within the mulled green sand mould; and these bonds are responsible for the moulds' strength (Odom, 1988)

The mixture of silicate sand, bentonite and water were weighed. Then the mixture was mixed using the mixer for about 10 minutes to get the homogenous mixture. At the same time, the moulding boxes were prepared and arranged on the flat area. The pattern of the dog bone then placed in the middle of the moulding box and the mixed of the silica sand and bentonite then placed in the moulding box, compressed layer by layer using the rammer. Parting powder is applied to the mould, for easy released of moulds and cores from pattern and core boxes. Then pattern is removed with the channel plug, leaving the mold cavity.

TERTIARY ZINC ALLOY

A zinc alloy with 3wt% aluminium and 2wt% magnesium was used for this study. Melting process of material use in this study was done using heating furnace with temperature range until 1000°C. In a furnace material which zinc, aluminium and magnesium have to be melt above their melting temperature in order to make sure that they are fully transform into liquid phase.

Table 2: Zinc, magnesium and aluminium characteristic

	Zinc	**Magnesium**	**Aluminium**
Physical properties	Bluish-grey metal	Lightest metal	Silvery colour and luster
Melting point	481°C	650°C	660°C
Boiling point	906°C	1107°C	2057°C

RESULTS AND DISCUSSION

PHYSICAL PROPERTIES

The mentioned method of mold is differing in composition of bentonite with 5-17%. Differ in the composition of bentonite and silica sand give differ in result. The physical properties are obtains from the surface and the hardness test. Lowest and highest percentage of bentonite gives a dull surface properties compare to the in between. The shiniest surface is from the 11% of bentonite. Meanwhile for the hardness test, the results show the same with the surface properties. The results are affected by many factors that included both the green sand properties and the casting process parameters. The casting process parameters that could affect the results include the temperature of the metal poured, the geometry of the casting (e.g. specific surface area) sand-to-metal ratio, the length of time before shakeout, etc (Kauffman et al. 1997; Crandell et al. 2002)


Sample 1


Sample 2


Sample 3


Sample 4


Sample 5


Sample 6

Sample 7

Figure 1: Surface properties for all the ratios

When molten metal is pored poured into the green sand mould, silica sand helps to absorb the intense heat and transfer this heat away from the casting. The porosity among the sand grains also provides a pathway for gates that are generated during the metal pouring to escape from green sand mould interior, thus reducing the possibility of gas related casting defects. The permeability of the green sand is primarily determined by the shape and size of the silica sand. Generally large and coarser grains provide more porosity than smaller and smooth grains (Ammen, 2000). Shape and size distribution of the silica sand also dictates the amount of bonding materials needed and the compressive strength the mould will achieve; also affect the quality of casting finish, with finer sand grains creating a smoother casting surface than coarser sand grains.

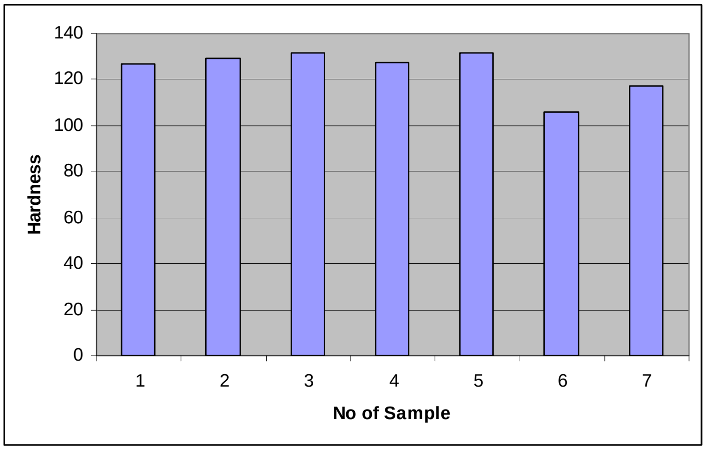


Figure 2: Hardness for the Zn-3Al-2Mg for 7 different moulds

The highest result for the hardness test is the sample number 5 that is 131.74 and the lowest is the sample number 6 that is 106.06. The sample number 5 is the ratio with 13% of bentonite, while the sample number 6 is the 15% of bentonite. It showed that the higher percentage of bentonite give the lower hardness result. The last two ratios gave the lowest hardness result compare to the lower percentage of bentonite in the green sand mould. Tensile strength graph showed that the highest strength is from the mould number 6 (112.113Mpa) which is containing 15% of bentonite in the green sand mould, while the lowest strength is mould number 4(77.892Mpa) with 11% of bentonite.

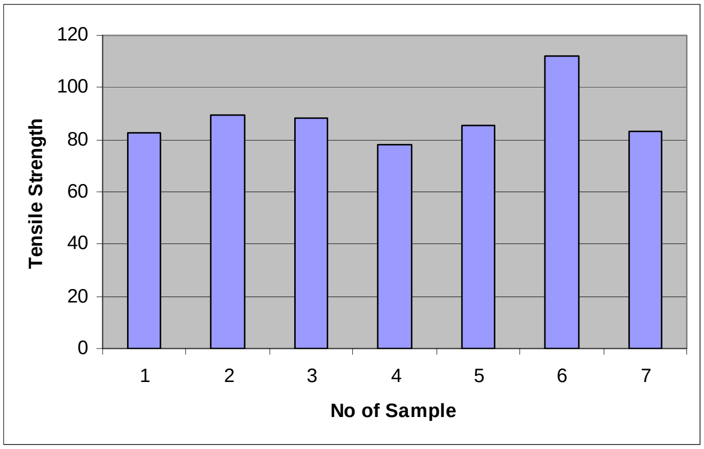
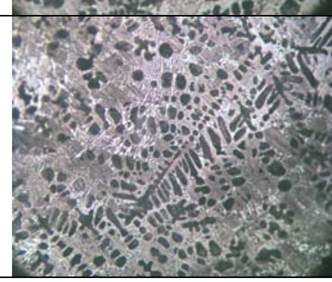
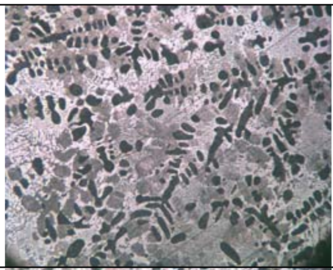
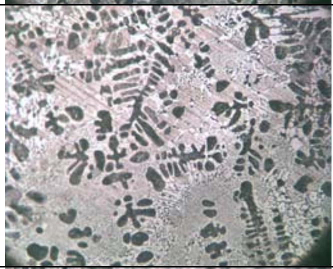
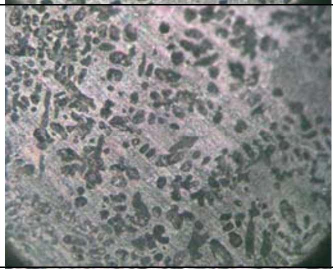
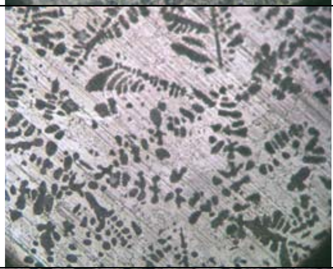
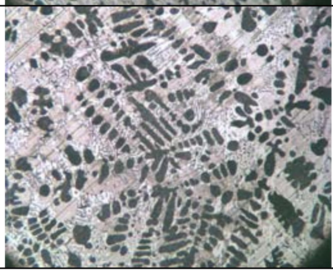


Figure 3: Tensile strength for the Zn-3Al-2Mg for 7 different moulds

When bentonite mulled with water and other compositions of green sand in a muller, the bentonites become hydrated, expanded, dispersed, and coat the surface of sand grains, where the sand, clays and water bond together via hydrogen. This film holds grains together and provides the different necessary strength (green, dry and hot strength) to maintain the shape of green sand mold during mold preparation and metal pouring (Smiernow et al., 1980; Kawatra et al., 2001). At higher water levels, clay platelets can no longer absorb the water, and the excess water exists as free water that simply coats the outer surface at clay platelets and impedes bonding. As a consequence, too much water caused a decreased in the green strength and this can lead to gas elated defects, poor surface finish and difficulty in the make out of sand (AFS, 1987). At lower water levels, clay is not fully activated, since the potential exists for further water adsorption and swelling; and this leads to brittle, friable molds that may crack prior to pouring or during pouring.

Table 3: Microstructures for the 7 different ratio

Sample Number	Microstructure
1	
2	

3	
4	
5	
6	
7	

CONCLUSIONS

I. The best ratios for the bentonite and silicate sand are the 13 % and 15% of bentonite.
II. Bentonite and silicate sand truely have an influence towards the hardness and the surface results.
III. All the mixture have nearly the same results for the hardness excepts for the two last ratios.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge FRGS and UniMAP for financial support.

REFERENCES

Yujue Wang, 2006, Study on the application of advanced oxidation processing in green sand foundries
Luther, N.B., Metal casting and molding processes 1007-1998.7,29-35

Smiernow, G. A,; Doheny, E.L,; Kay, J.G. 1980. Bonding mechanisms in sand aggregates. Am Foundry Soc. Transaction, 88, 659-682

Odom, I.E. 1998 Functional properties of Na and Ca bentonites in green sand system. Am Foundry Soc. Transaction. 96, 229-236

Odom, I.E. 1992. Chemical and physical factors that influence MB analysis of bentonites and system sand. Am. Foundry. Soc. Transaction. 100, 313-321

Amen, C.W. 2000, Metalcasting, Mc Graw-hill, New York,

Kawatra, S.K.; Ripke, S.J. 2001. Developing and understanding the bentonite fiber bonding mechanism. Miner. Eng, 14, 647-659

M.A.savas, S.altintas. 1993. The microstructural control of cast and mechanical properties of zinc-aluminium alloys. Journal of material science 28. 1775-1780

Kauffmann, P.; Voigt, R.C. 1997. Empirical study of impact of casting process changes on VOC and benzene emission levels and factors, am. Foundry soc. Trans. 105, 297-303

Crandell, G.R.; Knight, S.M,; Schito, J.F,; Rarick, T.W. 2002. An examination of the effects of process variables on air emission from metal casting. Am. Foundry soc. Trans. 110, 1311-1320