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Experimental Investigation of Aluminium-copper Alloy Synthesized using Powder Metallurgy Route

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Abstract—*Aluminium and Aluminium alloys have been the material of research for the last few decades due to their large weight reduction potential, high plasticity, good machinability and low cost. Powder metallurgy is the processing technique which involves processing of material powders using various steps like, production of material powders, mixing of powders, compaction and then followed by sintering and secondary operation. Due to various steps many controllable factors come into picture like, composition, compaction pressure, sintering time, temperature, heating rates, holding time etc. which effects the quality of the product in the form of many mechanical and microstructural properties. This paper mainly involves the study of the sintered density by varying the properties like, compaction pressure, sintering temperature and sintering time while considering the all other factors to be constant. The variation of sintered density was analyzed with the help of Taghuchi's design of experiment approach by using MINITAB 17. The plots were obtained showing the optimized values of compaction pressure, sintering time and sintering temperature for the sintered density using L9 array.*

1. INTRODUCTION

Powder metallurgy is used to produce uniform and fine microstructural metal parts. Various materials can be combined to produce a new component having unique properties. Some difficult to machine materials like, ceramics, refractory materials etc. can be easily produced using this technique [1]. Powder metallurgy has emerged as an advanced process from last few decades due to many unique advantages that other manufacturing methods might not give. The process of powder metallurgy starts form the metal powder production which is done with the help of some powder manufacturing techniques. After that the powders are mixed in some desired quantity and then some binders are added so that the localized bond formation could take place, after that the mixed powders are compacted i.e. a pressure is applied on the metal powders placed in the die thereby producing the green compact, the green compact does not have an adequate strength and is further heated in the furnace to sintering temperatures (0.7 to 0.9 times the melting temperature) and soaked for some time known as sintering time and then cooled. All these heating and cooling processes takes placed in the presence of some controlled atmosphere for this purpose nitrogen, helium or argon may be used. The main purpose of using the controlled atmosphere is to prevent the component from oxidation [2].

Aluminium and Aluminium alloys have drawn attention of researchers, scholars and industrialists due to their magnificent properties like large weight reduction potential, low density, low cost, and great corrosion resistance. Automotive sector is the largest user of Al parts that are used engines and chassis manufacturing [1]. Another major user of Al alloys is the aerospace industry. Specifically, the 2XXX series also known as duralumin, which is used in transportation and aircraft industries due to its heat treatment properties and excellent toughness particularly at higher temperatures.

C.D. Boland et al. [3] studied the industrial processing of Al-Cu- Mg P/M alloys and fund that the compaction pressure of 400Mpa followed by sintering at 600°C for 20 minutes will be the most appropriate condition. Also the addition of Sn has a positive effect on sintering behavior of the following alloy.

I.A. MacAskill et al. [4] studied the effect of magnesium, tin, and nitrogen on sintering behavior of Al and found that the addition of magnesium lead to improvement in the sintering response. Nitrogen does not prove to be a good sintering atmosphere.

Abdulwahab Ibrahim et al. [5] done experiments on Alumix 321 and found the optimum sintering conditions as ramp at 390°C for 20 minutes followed sintering at 630°C for 20 minutes under nitrogen atmosphere, the density achieved was around 98%.

The current work represents the optimum conditions for producing the powder metallurgy alloy of Aluminium 2XXX series. The composition used was, Aluminium- 95%, Copper- 4%, Magnesium- 0.5%, Silicon- 0.5%. The compaction was done at three pressures of 2, 3 and 4 Ton (250, 375 and 500 Mpa) respectively. The sintering was done at three temperatures, 450°C, 480°C and 510°C for three time periods of 30, 45 and 60 minutes respectively. All the sintering operation was performed on the tube type furnace and in the shielding atmosphere of Argon. The results were analyzed with the help of Taguchi L-9 orthogonal array using

MINITAB- 17. The sintered density was taken as response variable.

2. TAGUCHI'S DESIGN

Design of experiments is a statistical technique introduced by R.A. Fisher in 1920 to study the effect of various variables simultaneously in an experiment. Dr. Genechi Taguchi in 1940's carries out research with design of experiment techniques. Taguchi method was introduced in 1980's in USA and now it is the most popular available tools now a days that researchers used for their experiments. In Taguchi's design various factors are considered, the factors are input factors that could be controlled and that influences the process variables, various levels are assigned at the factor, level is the value that a factor assumes during an experiment. The output are known as resource variables and these are the variables that we want to minimize or maximize as per the requirement. All these data's are fed in an orthogonal array. An orthogonal array is the combination of various factors at various levels. The most common orthogonal array used for design of experiments in L9 which contains 3 factors each at three levels [6]. A general Taguchi's array is as shown below;

Sample	Factor 1	Factor 2	Factor 3
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

The values 1, 2 and 3 corresponds to the various levels of the factors. These arrays are created by MINITAB 17 software and the obtained resource variable in denoted in the another column and the design is analyzed and the final signal(desired) to noise(Undesired) ratio is obtained which helps in the analysis of the data.

3. EXPERIMENTATION

The experimentation starts from the material powder, for this purpose the different material powders like Aluminium, Copper, Silicon and magnesium fine powders with minimum 99% purity were purchased from the supplier. These powders were weighed using semi- micro weighing balance and added in the ration as specified below.

Aluminium- 95%

Copper- 4%

Silicon- 0.5%

Magnesium- 0.5%.

Isopropyl alcohol was used as the binder so as to ensure proper bonding in the green compact.

All the material powders were mixed thoroughly and then isopropyl alcohol was added in very fine drops to the mixture and the mixture was then poured in the die cavity and the compaction pressure was applied on the powders with the help of hydraulic press the capacity of the press was of 15 ton but the compaction was done at three pressures of 2, 3 and 4 ton respectively (250, 375 and 500Mpa). After compaction, the compacts of 10mm diameter and of almost same height were obtained, which are known as green compacts. These compacts take the solid shapes but does not have adequate strength and their porosity was also very high.

For the calculation of density, following formulas were used,

(1/Theoretical density)= (wt. % of Al/ Density of Al) + (wt. % of Cu/ Density of Cu) + (wt. % of Si/ Density of Si) + (wt. % of Mg/ Density of Mg).

The green and sintered densities were calculated using the formula,

Density= (mass/ Volume)

Volume= $\pi d^2 h/ 4$

Green density in %= (Green density/ Theoretical density)

Sintered density in % = (Sintered density/ Theoretical density)

The porosity is calculated by subtracting the percentage density from 100.

After compaction the dimensions of the green compacts were calculated and the mass was measured and then the green densities were calculated at the corresponding three pressures, the calculated values are given in the following table.

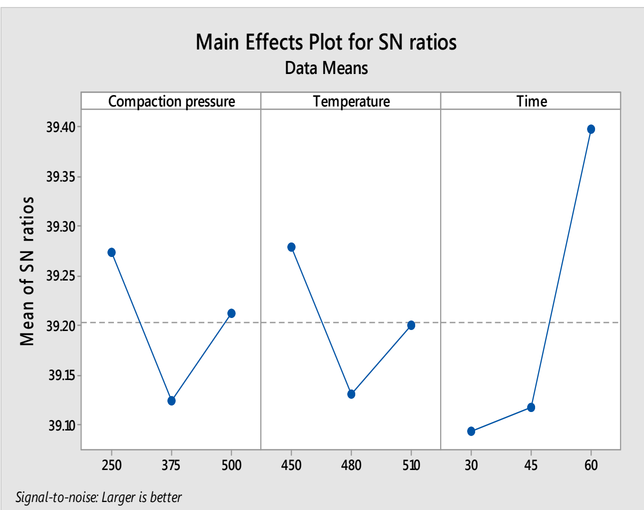
S. No	Compaction Pressure (Mpa)	Green density
1	250	83.2491
2	375	78.9170
3	500	81.1417

From the green compacts, it is evident that the green densities of the compacts was around 80% and it is maximum for the compaction pressure of 250Mpa and then decreases for the compaction pressure and then again increases.

The green compacts were then sintered under different operating conditions, i.e. the three values of sintering temperatures (450, 480 and 510°C) and Sintering time (30, 45 and 60 minutes). The whole array was made according to Taguchi's L9 array and was analyzed using MINITAB 17. The other parameters like heating rates, atmosphere was taken constant for each and every sample. The heating rate was taken constant as 10°C/M and Argon was used as the working atmosphere. After sintering the densities was calculated by measuring the dimensions of the sintered compacts. The measured densities values were then fed into the L9 array and the whole design is analyzed using MINITAB 17. The whole array obtained after measuring the sintered densities is as given below,

S. No.	Comp. Pressure (Mpa)	Temp. (°C)	Time (Min.)	Sintered Density (%)
1	250	450	30	91.58
2	250	480	45	88.73
3	250	510	60	95.74
4	375	450	45	91.95
5	375	480	60	91.65
6	375	510	30	87.66
7	500	450	60	92.59
8	500	480	30	91.05
9	500	510	45	90.37

The above array obtained was analyzed using the MINITAB 17 and the signal to noise ratio was obtained for each factor, the Larger the better is the desired in this response variable. The graphs were obtained and the rank of the each factor was also examined.



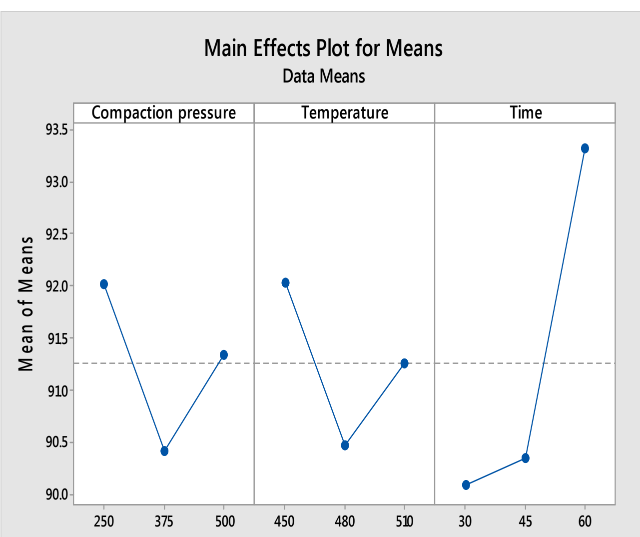


Table Response values for S/N ratio

S. No.	Comp. pressure	Temp.	Time
1	39.23	39.28	39.09
2	39.12	39.13	39.12
3	39.21	39.20	39.40
Delta	**0.15**	**0.15**	**0.31**
Rank	**2**	**3**	**1**

Table Response values for means

S. No.	Comp. Pressure	Temp.	Time
1	92.02	92.04	90.10
2	90.42	90.48	90.35
3	91.34	91.26	93.33
Delta	**1.60**	**1.56**	**3.23**
Rank	**2**	**3**	**1**

4. RESULT AND DISCUSSIONS

From the above analysis done it can be concluded that,

1). The mean of SN ration first decreases for compaction pressure and temperature and then increases near the mean values for the same factors. For time factor, the mean for SN ratio there is an increase in the response variable for the increasing values, the response increase from 30 to 45 minutes at lower rate and then increases sharply from 45 to 60 minutes.

2). As indicated from response tables the highest value of delta is of time factor i.e. the most significant factor in the analysis is the time factor.

3). The maximum density achieved is 95.74% for the 3rd sample no indicating the optimum conditions.

REFRENCES

1). Azim Gokce, Fehim Findik, Ali Osman Kurt (2011), "Microstructural examination and properties of premixed Al- Cu- Mg powder metallurgy alloy", Journal of Materials Characterization, 62, 730-735.

2).http://nptel.ac.in/courses/112101005/downloads/module_3_lecture _6_final.pdf.

3). C.D. Boland, R.L.Hexemer Jr., I.W. Donaldson, D.P. Bishop, (2013), "Industrial processing of a novel Al- Cu- Mg powder metallurgy alloy", Journal of Material Science and Engineering A, 559, 902-908.

4).I.A. MacAskill, R.L.Hexemer Jr., I.W. Donaldson, D.P. Bishop, (2010), "Effects of magnesium, tin, and nitrogen on the sintering response of aluminium powder", Journal of Materials Processing Technology, 210, 2252-2260.

5). Abdulwahab Ibrahim, Donald P. Bishop, Georges J. Kipouros, (2015), "Sinterability and characterization of commercial aluminium powder metallurgy alloy Alumix 321", Journal of Powder Technology, 279, 106-112.

6). http://Nutek-us.com/wp-s4d.html