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A STUDY OF INFLUENCE OF DENSITY ON AL-CU COMPOSITION DURING COMPACTION PROCESS

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ABSTRACT

Powder metallurgy is a technology used for producing machine parts and oil-impregnated bearings from a metal powder. Highly accurate products can be efficiently mass-produced, and for that the powder metallurgy is indispensable particularly in automobile industry. Therefore powder characteristics are important because they often determine the choice of a particular processing route. In general, a mixed powder that is a metal powder is moulded by compression and the resultant green compact is then dewaxed. Subsequently, in powder metallurgy, the compact is sintered at a temperature of about 550 °C.In this sintering process, the mixed metal powder forms an alloy, thereby increasing the strength of the compact. It is done under a protective atmosphere with or without fusion of a low melting point constituent only so as to develop metallic or metal like bodies with satisfactory strength, density and without losing the essential shape [1]. A cutting operation is then performed on the resultant sintered compact. Metal powders are produced in various methods such as atomization, shotting, stamping and ball milling but pot mill is preferable. Spherical and dendritic metal powders are produced by atomization methods and flake shaped metal powders are produced by ball milling method. For the investigation purpose a quantity of copper powder is added to aluminium powder and mixed well by using pot mill to get homogeneous mixture. The aim of this paper is to establish the correlation among flow rate, compaction and sintering process and densities of compact of 3 % of Cu in Al.

Keywords: Tap density, Theoretical density, Compact density, Flow rate, Compact.

1. INTRODUCTION

Aluminium P/M parts are used for their improved material characteristics or in some cases (e.g. complex shapes) because of their lower production cost. In most of the applications the P/M parts are used because of one (or more) of the following properties like high Young's modulus, low density, high room temperature strength, better high temperature strength and better wear resistance. The greatest variety of P/M parts are currently used by the business machine constructors because of light weight components and the light weight reduce inertia on startup and stopping of the machine or engine or parts of the engine. Hence light weight aluminium P/M parts have been used for drive belt pulleys, hubs, and caps and connection collars [2]. Other applications are also found in automotive components. The need for light, corrosion resistant materials to get a strong, higher temperature materials and this type of materials promote the interest for P/M aluminium parts. The strong point of P/M aluminium parts is probably the wide variety of alloy compositions which can be prepared, offering in principle the possibility of achieving a desired combination of properties. A lot of these alloys are currently still under investigation. It is well known that there are two distinct methods of compaction of the powders. For the investigation purpose ejection method is used.

2. EXPERIMENTAL METHODS

a) Powder mixing
b) Preparation of compacts
c) Compact coating
d) Sintering and
e) Testing

2.1. Powder Mixing

Mixing is the most common pre – compaction step in powder metallurgy. Theoretically any composition can be prepared starting from elemental powders [3]. In this experiment 30 gm of oxidized copper powder is mixed with 970 gm of aluminium powder in a pot mill for 4 hours in order to get a homogeneous mixture. The homogeneous mixing will improve the sintering ability, ejection of compact and strength of the compact.

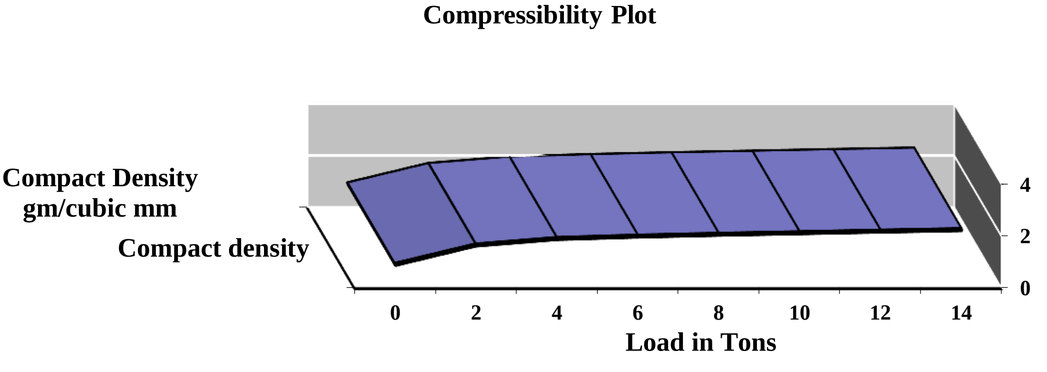
2.2. Preparation of Compacts

In this process the powder is filled in a die and it is compressed with rigid punches to form a dense compact and to get a smooth ejection from the die. 50 gm of mixed powder is compacted using a Hydraulic press by applying 18 tonnes on the green powder .The ejection load of the compact is 10200 Kgm. The samples with dimension of 15.70 mm diameter and 25.05 mm thickness were prepared based on 3 % weight of Cu in Al_2O_3 reinforcement. Weight of the compact is 13.40 gm. The friction interaction between powder and die wall plays an essential role [4] in powder compaction because it leads to density variation, increased compression and ejection forces and die wearing. These properties influence the later process of extrusion. The friction is reduced by coating a lubricant molybdenum disulphide on the die wall. The compact density is calculated for various loads .The compressibility ratio is calculated which is shown in the Table 1 and the corresponding compressibility ratio plot drawn is shown in the Mat lab Graph 1.

Table-1. Compact Density and Compressibility Ratio

Load in Tons	Compact Density ρ_c x 10^{-3} gm / mm^3	Compressibility Ratio ρ_c / ρ_{the}
0	0.9271	0.3365
2	1.6765	0.6085
4	1.9266	0.6993
6	2.0190	0.7328
8	2.089	0.7584
10	2.1488	0.7799
12	2.2115	0.8027
14	2.2688	0.8235

Graph-1. Compressibility Plot



2.3. Compact Coating

The green compact preferably further coated with a lubricant. This is because the lubricant can decrease the coefficient of friction between the green compact and a die. As a result, the generation of die galling and damage of the die can be suppressed. The lubricant is preferably zinc stearate. This makes the compounds to be excellent as an additional [5] component of the mixed powder for powder metallurgy product. The prepared green compacts are put in the muffle furnace and sintered at a temperature of 550°C and the sintering duration is 1 ½ hours. This duration is sufficient for the green compacts and it improved the strength when it was tested.

2.4. Sintering

A sintered compact has an excessively high strength from the viewpoint of a cutting operation. Due to this, the lifetime of a cutting tool used is shortened because of the high strength of the sintered compact. On the other hand, a green compact cannot be subjected to a cutting operation prior to sintering because the green compact is brittle. Accordingly, a technology is desired [6] by which the strength of a green compact prior to the sintering process is increased, so that the green compact can subsequently be subjected to a cutting operation and finally sintered. After sintering it is found that the height of the compact is 33.03 mm and the diameter of the compact is 27.90 mm and the weight of the compact is 50.4gm. It shows that the sintering process involves some mass transport. The geometry is changed and this may be due to the growth in pores.

2.5. Testing the Powder

Physical properties of the above said mixed powder is tested. The powder as it is produced is loose and there is a considerable swell. When the powder is compacted in the die, it is reduced in volume as most of the voids are filled up due to interlocking of the grains. The apparent density is 0.84608 gm / cc and the compression ratio after the compaction is calculated using the density of the compact and it is shown in the Table 2 and it varies between 2:1 /3:1. This factor of compression ratio is very important and it should be taken into consideration while designing the compaction dies [7] as the final shape and the size of the components which are produced on a mass scale should be uniform.

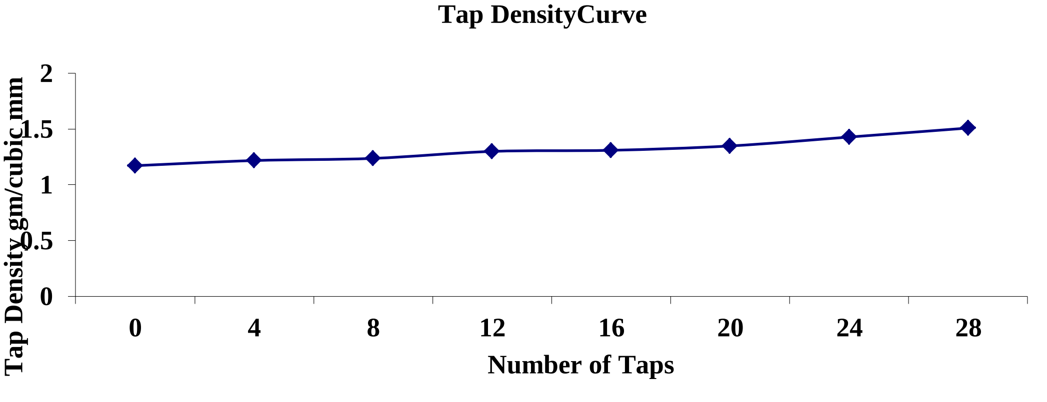
2.6. Tap Density or Load Factor

Load factor is the apparent density after the powder has been shaken down or consolidated by vibration. The necessity and importance of tap density is sometimes used as a basis of die design, especially where the die is subjected to vibration during filling. The tap density is calculated for various taps from 0 to 28 is shown in the Table 2 and the corresponding characteristic curve is shown in the Graph 2.The ratio of ρ_{tap} / ρ_{the} is within the limits.

Table-2. Compression ratio and Tap Density

Compact Density ρ_c x 10^{-3} gm / mm^3	Compression Ratio	Tap Density ρ_{tap} gm / mm^3 Number of Taps	ρ_{tap}	ρ_{tap} / ρ_{the}
0.9271	1.0957	0	1.1708	0.4249
1.6765	1.0981	4	1.2169	0.4417
1.9266	2.0277	8	1.2363	0.4487
2.0190	2.3862	12	1.2988	0.4714
2.089	2.4690	16	1.3688	0.4750
2.1488	2.5397	20	1.3477	0.4892
2.2115	2.6138	24	1.4275	0.5181
2.2688	2.6815	28	1.5082	0.5474

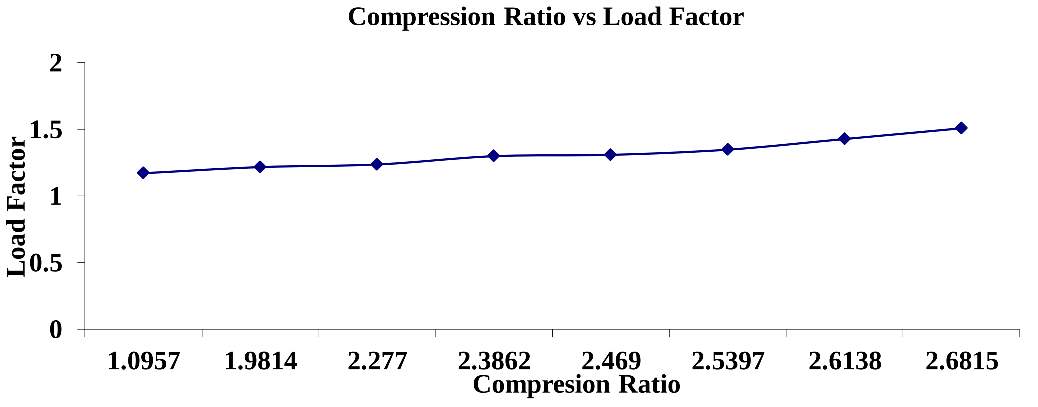
Graph-2. Number of taps Vs Tap density



2.7. Theoretical Density

The theoretical density of the loose powder for the 3 % Al-Cu composition is calculated as ρ_{tap} = 2.755 gm/mm ^{3} and the Flow Rate of the powder is 221secs for 50 gm of the loose powder. The fluidity of the powder is 0.226 gm / sec.The compression ratio against the load factor is plotted and it is shown in the Graph 3.

Graph-3. Compression Ratio vs. Load Factor



The result of the above graph is useful in tool design setting for the extrusion process. The ejection pressure in compaction process is calculated as 8.2521 K gm /mm ^{2} and the effective densities calculated for the 3% Cu wt in alumina is shown in the Table 3.

Table-3. Density Classifications

Composition	Compact Density ρ_c x 10^{-3} gm / mm ^{3} at 14 Tons	Tap Density ρ_{tap} gm/ m ^{3} at 28 th Taps	Green Density ρ_g gm / mm ^{3}	Sintered Density ρ_s x 10^{-3} gm / mm ^{3}	Theoretical Density gm / mm ^{3}	Apparent Density gm / mm ^{3}
3%Cu in Al_2O_3	2.2688	1.5082	8.407	2.4760	2.755	0.84608

3. RESULTS AND DISCUSSION

1. The effect of tapping on powder composition for various taps show good increase in the Tap Density.
2. By the application of increased compacting pressure, the compact density is shown good increase. Correspondingly the compression ratio is also in good increasing order.
3. The ratio of ρ_{tap} / ρ_{the} also shows good result & it increases with the increase in number of taps and the tap density.

4. It is observed that the green density, sintered density, theoretical density, tap density, & compact density having good correlation with each other and increased the strength properties in extrusion process.
5. The flow rate of the powder is ideal and it has good fluidity.

4. CONCLUSIONS

The apparent density has good impact on compaction and the compassion ratio is in the increasing order. The sintered powder and the sintered compact show the good result on sintered density. The ejection pressure is good such that the compact is ejected out without any crack during operation. The role of lubricant is also dominant in this point. The difference between dimensions of green compact and sintered compact showed that there is a comfortable growth in the grain size. Hence the present experimental investigation showed that it is possible to make powder metallurgy components from 3% Cu in Al_2O_3 reinforcement because the formation of thin film oxide on the surface protecting the alloy composition from corrosion. This feature is utilized in construction, buildings and household utensils.

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