Preparation of AL – 7075 RRR With Nano SiO_2 Through Powder Metallurgy

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ABSTRACT: Basically aluminum has less hardness and scratch resistance which is not much preferred in bearing materials of automobile parts. The prepared powder metallurgical composite will have higher dispersion of filler material which obviously improves the strength of composite at the same time it is also act as porous metal for continuous lubrication during work condition of ball bearing. The present work deals with the preparation of composite with different filler loading for finding the optimal filler loading with less agglomeration of filler which implies higher strength in terms of hardness and scratch resistance. The die was designed in such a way that it should withstand higher load conditions during powder compaction. Optimum filler loading was found at 15wt% of filler material as silica.

Index Terms: AL – 7075 RRR, Nano Size SiO_2, Acetone, Die, Muffle Furnace, Universal Testing Machine.

1. INTRODUCTION

Powder metallurgy (PM) is a term covering a wide range of ways in which materials or components are made from metal powders. PM processes can avoid, or greatly reduce, the need to use metal removal processes, thereby drastically reducing yield losses in manufacture and often resulting in lower costs.

3. EXPERIMENTAL PROCEDURES

3.1 - POWDR WEIGHING - The starting step is weighing of composite here we have employed electronic weighing machine before weighing the composite we make sure that no foreign particles are present inside the weighing pan. Next butter paper is taken and it is kept inside the pan using spatula powder is poured in to the butter paper. Here in this project we have decided on making 7 samples those are as follow.

1.) Pure Aluminum – 7075 RRR (30 gms)
2.) Pure Aluminum – 7075 RRR+ 2%wt SiO_2
3.) Pure Aluminum – 7075 RRR + 5%wt SiO_2
4.) Pure Aluminum – 7075 RRR + 10%wt SiO_2
5.) Pure Aluminum – 7075 RRR + 12%wt SiO_2
6.) Pure Aluminum – 7075 RRR + 15%wt SiO_2
7.) Pure Aluminum – 7075 RRR + 20 %wt SiO_2

After weighing the 7 samples powder mixing has to be done for that process we have employed planetary ball milling for equal mixing of composite.

Weighing Machine

3.2 POWDER MIXING OR BLENDING

For powder mixing planetary ball milling is employed the main reason behind the usage of ball milling is as the Al – 7075 RRR & silicon oxide are in Nano size. Before pouring the powder in to the vail we have to make sure the vails are free from foreign particles or not. In order to ensure this first of all the vails are cleaned neatly with water and wiped with tissue paper. Second step the vails are cleaned with clentron (soap based cleaning agent) in this state it removes sticky and porous particles present on the vails after cleaning the vails are wiped gently with tissue paper. In the third step vails are cleaned with acetone and wiped gently with tissue paper.

Before installing the vails in to the sun bowls calculations are performed for blending.

Vail.no – 1 – Tungsten Carbide balls – 8*12 mm – 96gms , 20*10 mm – 200 gms.

Vail.no – 2 – Tungsten Carbide balls – 8*12 mm – 96gms , 20*10 mm – 200 gms.

Note – The above calculations are taken under BCR as 1:10.

After Tungsten Carbide balls are dropped in to the vails and samples of powder that are weighed are poured in to the vails. Now the vails are closed with plates and placed inside the sun blows present in planetary ball milling machine. Now after installing these vails 250 rpm, 30 min ON & OFF time are maintained.

PLANETARY BALL MILLING FEATURES & PARAMETERS

Planetary ball mill system makes grinding extremely fast and efficient. Rotation of base plate provides the centrifugal force to the grinding balls and independent rotation of bowls in opposite direction makes the balls to hit the inner bowls several times more, because of the short returned path. Since the bowls are rotating in opposite direction, a considerable part of grinding is done due to friction.

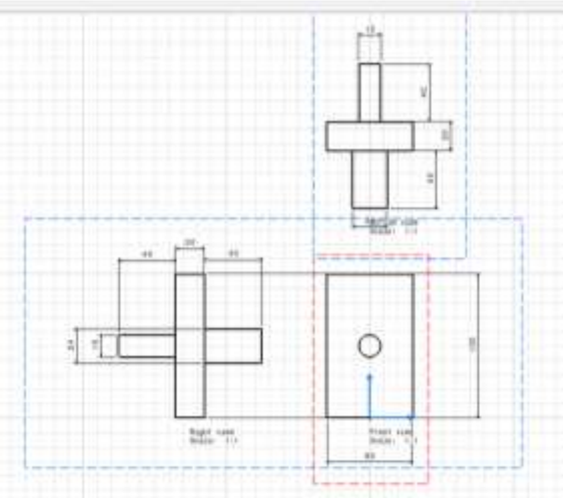
Tungsten carbide balls in vail

Composite metal matrix powder in vail

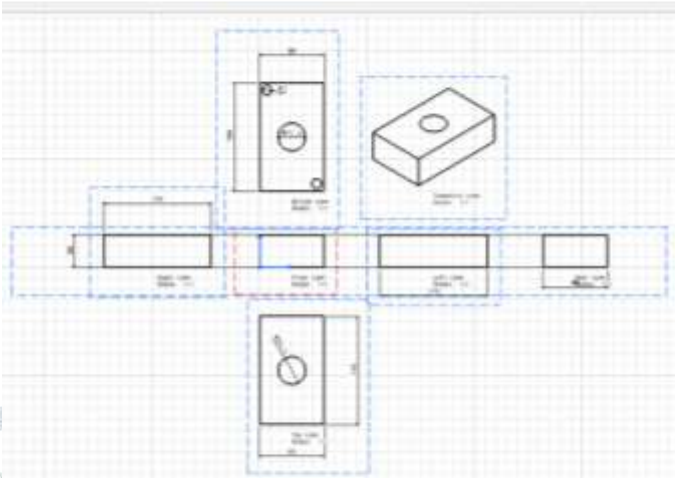
In Smart Ball milling machine

DIE DESIGN

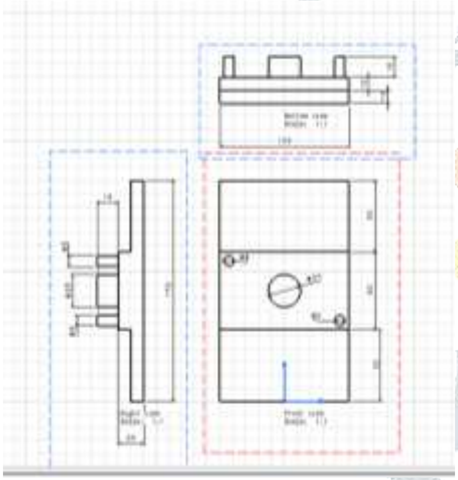
2 – D DIE DRAWINGS



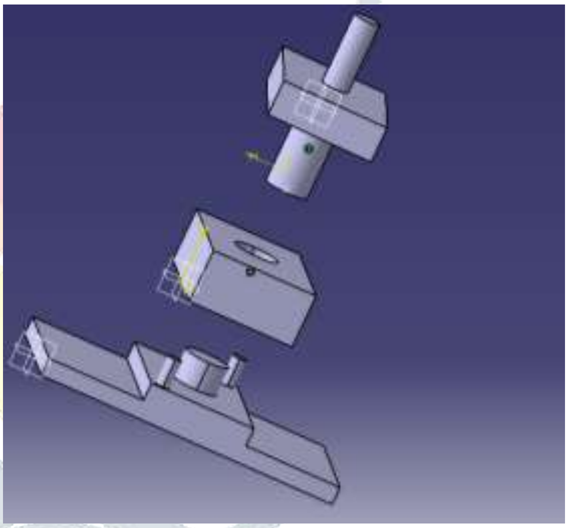
2-D Die Drawing top part



2-D Die Assembled parts



2-D Die Drawing of Bottom die part



3-D assembly view

PROBLEMS ENCOUNTERED DURING BALL MILLING

Improper cleaning of vail result in formation of intermediate compound

Loss of die shank material while compacting 15% sio_2 composite powder.

PREHEATING OF COMPOSITE

Here by preheating the composite we have eliminated the usage of binder for the composite. By preheating the composite the bonding of particles is improved. The mechanical, weldability, electrical conductivity of the particles are improved. Here the preheating is done in muffle furnace. First the muffle furnace is basically at room temperature and it is reached set to temperature of 350^{o} c and then the composite is kept in the muffle furnace for 30 minutes. After 30 min the composite is ready for compaction in the UTM machine.

Muffle Furnace

COMPACTION OF COMPOSITE IN UTM

The compaction of the preheated powder is performed in 100 tonne Universal Testing Machine machine.

100 Tonne Universal Testing Machine

Sample 1- Pure Aluminum – 7075 RRR - 30 grams

- Ball Milling Speed- 260 RPM (Planetary Ball Milling).
- Time -10 Minutes.
- Compaction Pressure – 170 KN (UTM).
- Pre Heating Temp- 350^{0}C, time is 30 minutes.
- Sintering Temperature- 590^{0}C, Holding Time is 90 minutes, Cooling Time is 2880 minutes (Muffle Furnace).
- The above Parameters are maintained constant for all the other samples.

Sample – 1 Pure Aluminum – 7075 RRR

Pure Al – 7075 RRR – Mass – 14.19 gms, r = 1.25 cm, h = 1.1 cm

Volume - πr^2h – 3.14*12.5²*11 = 5399.61 mm³ ……… Eq.1

$$\rho = \frac{14.19}{5399.61} = 2.62 \times 10^{-3} \text{ gm/mm}^3 \quad \text{………… Eq.2}$$

$$\text{Pressure} = \frac{Force}{area} = \frac{170*10^3}{\pi \times 12.5*12.5} = 347\ Mpa \quad \text{……….. Eq.3}$$

Sample 2- Aluminum 7075 RRR (30 grams) + 2% SiO_2

Sample 2 – Al – 7075 RRR + 2%SiO_2

Al – 7075 RRR + 2% wt sio_2 – Mass – 14.19 gms ,r – 1.25 cm , h = 1.1 cm

$$\rho = \frac{14.19}{5399.61} = 2.62 \times 10^{-3} \text{ gm/mm}^3 \quad \text{……….. Eq.4}$$

$$\text{Pressure} = \frac{Force}{area} = \frac{170*10^3}{\pi \times 12.5*12.5} = 347\ Mpa \quad \text{……….. Eq.5}$$

Sample 3- Aluminum 7075 RRR 30 grams + 5% Sio2

Sample 3 – Al – 7075 RRR + 5%SiO_2

Al – 7075 RRR + 5% wt sio_2 – Mass – 11.41 gms ,r = 1.25 cm , h = 1 cm

$$\rho = \frac{11.41}{4906.25} = 2.32 \times 10^{-3} \text{ gm/mm}^3 \text{ ……….. Eq.6}$$

$$\text{Pressure} = \frac{Force}{area} = \frac{170*10^3}{\pi \times 12.5*12.5} = 347\ Mpa \text{ ………… Eq.7}$$

Sample 4- Aluminum 7075 RRR 30 grams + 10% Sio2

Sample 4 – Al – 7075 RRR + 10%SiO_2

Al – 7075 RRR + 10% wt sio_2 – Mass – 10.84 gms ,r = 1.25 cm , h = 1 cm

$$\rho = \frac{10.84}{4906.25} = 2.209 \times 10^{-3} \text{ gm/mm}^3 \text{ ………… Eq.8}$$

$$\text{Pressure} = \frac{Force}{area} = \frac{170*10^3}{\pi \times 12.5*12.5} = 347\ Mpa \text{ …………Eq.9}$$

Sample 5- Aluminum 7075 RRR 30 grams + 12% Sio2

Sample 5 – Al – 7075 RRR + 12%SiO_2

Al – 7075 RRT + 12% wt sio_2 – Mass – 13.8 gms ,r = 1.25 cm , h = 1.1 cm

$$\rho = \frac{13.8}{5399.61} = 2.55 \times 10^{-3} \text{ gm/mm}^3 \text{ ....Eq.10}$$

$$\text{Pressure} = \frac{Force}{area} = \frac{170*10^3}{\pi \times 12.5*12.5} = 347\ Mpa \text{ ....Eq.11}$$

Sample 6- Aluminum 7075 RRR 30 grams + 15% Sio2

Sample 6 – Al – 7075 RRR + 15%SiO_2

Al – 7075 RRR + 15% wt sio_2 – Mass – 13.95 gms ,r = 1.25 cm , h = 1.1 cm

$$\rho = \frac{13.95}{5399.61} = 2.583 \times 10^{-3} \text{ gm/mm}^3 \text{ .... Eq.12}$$

$$\text{Pressure} = \frac{Force}{area} = \frac{170*10^3}{\pi \times 12.5*12.5} = 347\ Mpa \text{ .... Eq.13}$$

Sample 7- Aluminum 7075 RRR 30 grams + 20% Sio2

Sample 7 – Al – 7075 RRR + 20%SiO_2

Al – 7075 RRR + 20% wt sio_2 – Mass – 9.9 gms, r = 1.25 cm, h = 1 cm

$$\rho = \frac{9.9}{4906.25} = 2.01 \times 10^{-3} \text{ gm/mm}^3 \text{ .... Eq.14}$$

$$\text{Pressure} = \frac{Force}{area} = \frac{170*10^3}{\pi \times 12.5*12.5} = 347\ Mpa \text{ .... Eq.15}$$

The sintering of composite is done at 590^0 c heating time 120 min holding time 90 min, Cooling time 2880 min.

5. CONCLUSION

From present work it has been concluded that with higher loading condition of filler material has increased in dispersion up to 15wt% of silica in Aluminum matrix powder. Increase of filler material in to the matrix beyond 15wt% results poor binding in compaction process. Composite was analyzed for compaction pressure by rule of mixtures for density. Design of die made a considerable impact in compaction process in composite preparation. Preheating has great impact on compaction process which drove powder particles into plastic region. Powder particles in plastic region reached semi melting point of pure aluminum 7075 RRR which helped in getting perfect blended and bind of powder particles. Sintering temperature of 580^0C was maintained for holding of composite for one and half hour with consequent furnace cooling. Further testing is need to be carried in getting mixtures through SEM, XRD and mechanical testing need to be carried in order to get justification for silica as filler material.

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