Barrelling Behaviour of Copper Powder Preforms under Different Lubricating Conditions

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ABSTRACT

The advances in recent technology has forecasted for producing near net shape of the products. Further the netshape products are subjected to cod upsetting for obtaining a final shape of products. This work explains the experimental determination of friction factor 'm' of copper powder preforms under various lubrication conditions. The rings of standard ratio 6:3:2 were produced by keeeping constant compacting pressure of 388.8MPa and further sintered at 725±10^{0}C and 750±10^{0}C and were tested. By using a digital vernier calipper the reduction in internal diameter and reduction in height of the preforms were measured. The different lubrication conditions were used such as Zinc stearate, MoS_2, Graphite and dry condition. Graph was plotted between the percentage reduction in internal dimeter and percentage reduction in height for different lubricants considered.Care was taken to place the specimen axially between the top and bottom platens. And the graphs between percentage reduction in internal diameter and compression load, percentage reduction in height and compression load were established.

KEY WORDS: Friction factor, Powder performs, Sintering, Lubricants.

1. INTRODUCTION

In many of the bulk forming processes, the friction between the workpiece and tooling plays an important role. The frictional conditions between the workpiece and tooling play important role for the metal flow patterns and the generation of defects. Even though there are number of methods have been developed to quantify the interface friction, the ring compression test is considered as the chief one. Based on the theoritical and experimental work of (Kunogi1954; Kudo, 1960, 1961; Avitzur, 1964; Male and Cockroft, 1964-65; Hawkyard and Johnson, 1967; Burgdorf, 1967), the ring compression test provides a measure of friction through a interrelation between the height reduction and the change in the internal diameter of the ring. Many of these efforts, however, have focused on the deformation of fully dense materials. Although the deformation and densification of porous bodies have been studied extensively, (Fleck, 1992; Arzt, 1983; Shamasundar, 1995; Dutton, 1995), there has been no significant effort to model or measure interface friction during processing of such materials. For example, the work by Im (1985; Oh, 1987), focused solely on the compression of porous materials to revealbthe broad applicability of the Finite Element Method(FEM) for porous materials. This work reports on the systematic study of application of the ring compression test for copper powder preforms. The specific objective of this work was to estimate the interface friction between the tooling and porous workpiece for several lubrication conditions.

2. EXPEERRMENTAL DETAILS

A die (fig.1) was designed and produced to prepare hollow ring specimen ratio of 6:3:2 (Outer diameter : inner diameter:height). Copper powder was obtained from the MEPCO Ltd., Tamilnadu, India. The purity of metal powder was found to be 99.8%. Zinc stearate of quantity 1% of the mass of the Copper powder was added to act as lubricant during Compacting and mixed by a mixer. Zinc stearate was also applied over the outer surface of the punch and the inner surfaces of the die. Preforms were prepared (fig.2) by applying a compacting pressure of 388.8 MPa. By applying constant pressure and mass of powder the density of the compacts were maintained as approximately constant. A muffle furnace was used to sinter the preforms in two different conditions such as 725° C and 750° C. At room temperature, the ring compression test(RCT) was carried out on 2MT hydraulic compression testing machine. The dial indicator of the compression testing machine recorded the amount of load required for the each strain level. The specimens were kept concentric with the top and bottom platens during the test. The density, height, internal diameter, internal contact diameter, outside diameter and outside contact diameter of the preforms were measured before and after deformation. Specimens were subjected to compression loads from 407.3MPa to 666.5Mpa, under the lubricants namely Zinc stearate, Graphite, MoS_2 and in dry lubrication condition. The density of the preforms were measured based on Archimedes's Principle. The friction factor 'm' of corresponding specimens were calculated by using the values of density and poison's ratio of each specimen.

Figure.1. Die set up for ring preforms

Figure.2. Ring specimen before deformation

Figure.3. Ring specimens after deformation

3. RESULTS AND DISCUSSIONS

For different lubrication conditions, the friction factor value for different sintering temperatures of produced ring preforms is calculated by following formulae,

The final density of the powder preforms is given by

$$\rho_f = \left[\frac{a_0}{a_f}\right]^2 \frac{h_0}{h_f} \rho_0$$

Poisson's ratio is given by.

$$\upsilon = 0.5\rho^2$$

<u>Simple upsetting with friction</u>

$$\frac{p}{\sigma_O} = \frac{2\upsilon q}{\sigma_O} + \left\{1-2\left[\frac{q}{\sigma_O}\right]^2\left(1-\upsilon-2\upsilon^2\right)\right\}^{\frac{1}{2}}$$

Where,

q : Internal radial strees

p : Normal pressure

$$q = 2m\tau_O\left[\frac{a_O - a}{h}\right]$$

According to Von-Mises

$$\tau_O = \frac{\sigma_O}{\sqrt{3}}$$

So,

$$\frac{p}{\sigma_O} = \frac{4m\upsilon}{\sqrt{3}}\left[\frac{a_O - a}{h}\right] + \left[\frac{1-8m^2\left(1-\upsilon-2\upsilon^2\right)}{3}\left[\frac{a_O - a}{h}\right]^2\right]^{\frac{1}{2}}$$

Finally the friction factor, m is given by

$$m = \sqrt{\frac{3\left[\left(\frac{p}{\sigma_O}\right)2-1\right]}{8\left[\frac{a_O - a}{h}\right]2\left[4\upsilon^2 - 1 + \upsilon\right]}}$$

Finally Friction factor 'm' is tabulated as following by the observed values.

Table.1. Friction factor under 725°C

Lubricant	**Sintering Temperature °C**	**Friction Factor 'm'**
Dry friction	725	0.77
Zinc stearate	725	0.34
Graphite	725	0.27
MoS_2	725	0.21

Table.2. Friction factor under 750°C

Lubricant	**Sintering Temperature °C**	**Friction Factor 'm'**
Dry friction	750	0.77
Zinc stearate	750	0.34
Graphite	750	0.27
MoS_2	750	0.21

Major findings that can be drawn from the present investigations are "the interface friction is reduced to greater extent when MoS_2 is used as lubricant during cold upsetting of copper powder pre-forms".

4. CONCLUSIONS

The major findings that can be drawn from the present investigations are as follows.

- It is observed that the friction factors of following lubricants namely Zinc Sterarate, Graphite, MoS_2, and dry lubrication are found as 0.34, 0.27,0.21 and 0.77 respectively for copper powder preforms.
- It is found out that the value of friction factor of lubricants not varies with the sintering temperature.
- The deformed contact diameter of the Copper Powder cylinder preform increases with decrease in friction factor value. But the contact diameter is lesser than the bulge diameter (D_b) for the respective lubricant for a given strain.
- The final height for a given strain condition increases as the 'm' value increases.

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