Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

SIZE EFFECT ON FRICTION IN FORWARD EXTRUSION PROCESS OF AA6063/SIC 5 %

Jayaseelan.V[1], Kalaichelvan.K[2], Jayaraman.P[1]
[1]Department of Mechanical Eng., Prathyusha institute of Technology and Management. Tiruvallur.
[2] Department of Ceramics Technology, Anna University, Chennai.
***Corresponding author: Email: jayaseelan.mech@prathyusha.edu.in**

ABSTRACT
Friction is a kind of response occurring during relative motion in extrusion process. Friction is varying with respect to interface condition, due to surface the friction may maximum or minimum. In metal forming, the determination of interface friction there are many methods existing. In the present work friction determined by forward extrusion, the two different height work piece materials is extruded and from the variation in their extrusion load the friction is calculated. Two different height materials are extruded in different area reduction die. Friction values are maximum in the case of the reduction ratio is high.

Keywords: Reduction ratio, Friction, Hardness, Microstructure.

INTRODUCTION

The friction phenomena are considered to be one of the most essential topics for the metal forming process. The evaluation of friction is a complex matter, which depends on both material and interface local conditions, such as temperature, strain, strain rate, flow stress, normal pressure and surface roughness. Reliable data of forming force and deformation work can be obtained only if the frictional Conditions on the active surfaces of the subsystem "component surface/tool surface" are determined by experimentally obtained values of frictional forces and by the partial coefficients of friction of the metal forming process. The recent trend towards miniaturization of products and technology has produced a strong demand, when scaling down a component from conventional to micro level the grain size of the microstructure changes and also the friction factor value will change. When a forming process is scaled down to micro dimensions, the microstructure of the work piece, the surface topology of the work piece and that of the tooling remain unchanged. The material of the work piece cannot be considered as a continuum due to the large share of volume occupied by an individual grain. Thus, the micro forming process imitations are largely influenced by the work piece dimensions and this is commonly referred to as the size effect. In this paper Al/SiC 5% Composites were extruded in hot conditions. Hardness, surface roughness of the components compared with as machined components and also interface friction factor is calculated.

EXPERIMENTAL WORK

Experimental Procedure & Materials used: Specimens were prepared by Stir Casting process of SiC 5 % Volume fraction with AA6063. The dimensions of specimens were 12, 8 and 4 mm diameter and 10, 15 mm lengths were used. Die and punch was made of Oil Hardened Non-shrinking Steel (OHNS) and hardness 45 HRc. Dimensions of extrusion dies were as 12:2, 8:4 and 4:2. Graphite lubricant was applied inside the die as well as outside the punch. Specimens were kept inside the Die. Die assembly kept in press and extrusion was performed at 300^oC temperature. For every 0.5 mm billet movement corresponding load was noted and maximum load also noted for every specimens. This is the load required to fill the die. Once the die was filled that was the maximum load, further pressing load has been decreases. The same procedure was repeated for the all the specimens for both die.

Theoretical Analysis of Friction Factor: The total extrusion load required to produce deformation is as follows:

$$F_T=F_d+F_c+F_e \qquad (1)$$

Where,
F_T – Total extrusion load,
F_c – Friction force between billet and container,
F_d – Load required to fill the die
F_e – Force required to form extruded pin
The total extrusion load can be written as

$$F_{T1}=F_{d1}+F_{c1}+F_{e1} \qquad (2)$$

$$F_{T2}=F_{d2}+F_{c2}+F_{e2} \qquad (3)$$

Equation 2 is for first sample and equation 3 is for second sample. In forward extrusion the maximum load is reached as soon as the die is filled completely with the work piece material. So F_{d1} and F_{d2} are same value. As the punch is moved by ΔL, then change in the punch load would be ΔF, and from Equation (2) and (3)

$$(F_{T1}- F_{T2}) = (F_{c1}- F_{c2}) + (F_{e1}- F_{e2}) \qquad (4)$$

$$\Delta F = \tau\, [\pi d_c L_{c1}- \pi d_c L_{c2}] + \tau\, [\pi d_e L_{e1}- \pi d_e L_{e2}] \quad (5)$$

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

$$\Delta F = m \frac{\sigma_o}{\sqrt{3}} [\pi d_c[\Delta L_c] + m \frac{\sigma_o}{\sqrt{3}} [\pi d_e[\Delta L_e] \quad (6)$$

$$\Delta F = m \, \pi \frac{\sigma_o}{\sqrt{3}} [d_c \Delta L_c + d_e \Delta L_e] \quad (7)$$

Or

$$m= \frac{\sqrt{3}\Delta F}{(d_c \Delta L_c + d_e \Delta L_e)\sigma_o \pi} \quad (8)$$

The friction factor m can obtain by evaluating all parameters in this Equation (8).

m = Friction factor
ΔF = Difference in the punch load - N
σ_o = Flow stress – N/mm^2

RESULTS AND DISCUSSION

Friction factor: The maximum load corresponding to the billets of lengths 15 mm and 10 mm were 24 KN and 10.4 KN respectively. The difference between maximum load corresponding to billets of length of 33 and 25 mm is 24-10.4=13.6 KN (4:2). Similarly for 8:4 and 12:2 die were the change in load are 42 KN and 150 KN. The same will be used to find out the friction factor for the corresponding die.

Table 1. Load, Displacement Values and Friction Factor

Die (I:O) mm	Lc (mm)		Le (mm)		ΔF (KN)	Friction factor (m)
	L_{c1}	L_{c2}	L_{e1}	L_{e2}		
4:2	3.5	2.1	4.2	6.3	13.6	0.384
8:4	2.8	0.4	1.5	5.8	42	0.318
12:2	5.6	12	7.9	13	150	0.475

From above tabulation, friction factor of 4:2 die was 0.384, friction factor of 8:4 die was 0.318 and friction factor of 12:2 die was 0.475. If area reduction is maximum, friction factor value is maximum for 12:2 die. In 8:4 die friction factor value was 0.318 and in 4:2 die friction factor values was 0.384. Due to Size effect friction factor value is maximum in 4:2 die compare with 8:4 die. This is due to surface area to volume ratio was more for smaller die (4:2). From this for higher reduction ratio as well as smaller size die has maximum friction factor.

Figure 1. Extruded specimen 4:2

Figure 2. Extruded specimen 8:4

Figure 3. Extruded specimen 12:2

Extruded specimen of 4:2, 8:4 and 12:2 are shown in figure 1-3. Micro structure is captured by Biovis material software. Extruded specimen has uniform particle distribution as shown in Fig 6 as compared with Fig 4 & Fig 5. Further specimens were taken into hardness test and microstructure analysis and also due to thermal softening hardness values reduce and there is small variation in grain size as compare with as cast specimens**.**

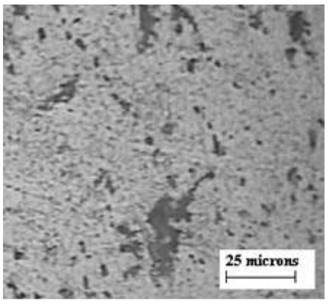

Figure 4: Micro structure of Billet

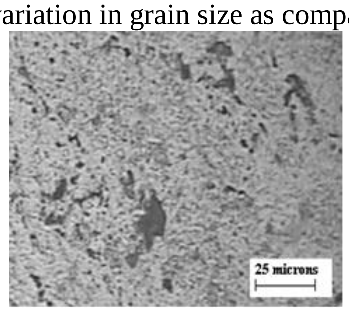

Figure 5: Micro Structure of Billet in Die Part

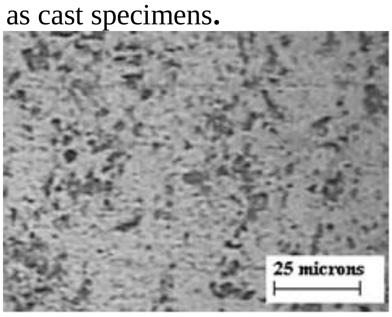

Figure 6: Micro Structure of Extruded Material

Hardness and Surface roughness

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

Hardness value of the extruded billet have less value compare to as cast specimen and also die part have less hardness compare to container part. Finally extruded pin have less value compare to die part and container part, this value reduces due to blow holes are cured and material has soften due to thermal softening. Hardness was measured by micro vicar's hardness testing machine and the average hardness values of container, die part and extruded are 98, 91 and 84 VHN. Average surface rough of extruded specimen has 48 µm but before extruded specimen that is machined specimen has 61 µm, from this extruded specimen has very good surface finish.

CONCLUSION

Al/SiC 5 % composites were extruded with Die 4:2, 8:4 and 12:2. Heating the billets material flow stress value is reduced and also load required to deform of billet is minimum. In 12:2 die has maximum load required to deformation and also it has maximum friction factor value, because of it has high reduction ratio, But in case of 4:2 die have 0.384 friction factor value and 8:4 die has 0.318 friction factor value. For high reduction area specimen has friction value high this is due to the ratio of surface area to volume of specimen has maximum for 12:2 die. Extruded specimen has good surface roughness compared to stir casting specimens and also hardness values reduced due to thermal softening and particle distribution is uniform.

REFERENCES

Linfa Peng, Xinmin Lai, Hye-Jin Lee, Jung-Han Song, Jun Ni, 2010, Friction Behavior Modeling and Analysis In Micro/Meso Scale Metal Forming Process, Materials and Design, Elsevier, UK, Volume 31, pp. 1953–1961.

Schikorra, M, Donati, L, Tomesani, L, Kleiner, M, 2007. The role of friction in the extrusion of AA6060 aluminum alloy, process analysis and monitoring, Journal of Materials Processing Technology, Elsevier, UK, Volume 191 (2007) 288–292.

Wagener, H.W and Wolf, J, 1994. Coefficient of Friction in Cold Extrusion, Journal of Materials Process Technology, Elsevier, UK, Volume 44, pp. 283-291.

Neil Krishnan, Jian Cao and Kuniaki Dohda, 2006, Study of the Size Effects on Friction Conditions in Micro extrusion-Part I: Micro extrusion Experiments and Analysis, Journal of Manufacturing Science and Engineering, Volume 129, pp. 669-676.

Jian Cao ,Neil Krishnan, Zhong Wang, Hongsheng Lu, Wing K. Liu, 2004, Micro forming: Experimental Investigation of the Extrusion Process for Micro pins and its Numerical Simulation Using RKEM, Journal of Manufacturing Science and Engineering, ASME Volume 126, pp. 642-652.

Bakhshi M. and Jooybari, 2002, A theoretical and experimental study of friction in metal forming by the use of the forward extrusion process, Journal of Materials Processing Technology, Elsevier, UK, Volume 125, pp. 369-374.