

Investigation of Geometry under Different Lubrication Conditions in Cold Upset Forging of Solid Aluminium Rings

A.Sathish¹, P.Pramod Kumar²

PG Student (AMS), Department of Mechanical Engineering, Malla Reddy Engineering College, Secunderabad, TS,
India¹,

Associate Professor, Department of Mechanical Engineering, Malla Reddy Engineering College, Secunderabad, TS,
India².

ABSTRACT: The technology advancement has envisaged going for near net shape of the produces. Also, near net shapes formed are again cold upset for obtaining a final shape of the Product. This work deals with an experimental, theoretical and analytical determination of friction factor 'm' for Solid aluminum Cylinders under different lubricating conditions. The aluminum ring having a standard ratio specified by the Male and Cockcroft (6:3:2) with a dimension of Outer diameter: inner diameter: Height, 36:18:12 is prepared to carry the ring compression test, to determine the friction factor between the interface of the work piece and die. Different lubrication conditions are applied such as grease, wax ,soap ,boric acid and no lubricant. The friction factor is sensitive to contact between the specimens and die. When the lubricant applied, the aluminum ring dimensions are change. The change in dimension, outer diameter, internal diameter, and reduction in height, using the standard calibration curve available for friction conditions by Male and Cockcroft is used to determine the friction factor of material. The cylindrical billets are compressed between the rigid dies after the lubricant is employed at the die billet inter face using UTM.after each incremental strain parameters of the geometry namely contact diameter, bulged diameter and barrel radius are tabulated. The load required for the deformation of the material also investigated and is compared for all the lubrication conditions.

KEYWORDS: Friction factor, different lubricant conditions, ring compression test, cylindrical compression test.

1. INTRODUCTION

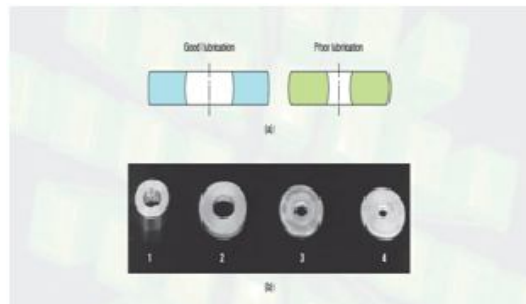
Friction at the interface of die/work piece is an important variable and has significant effects on both the work piece and process variables such as deformation load, metal flow and surface quality, and internal structure of the product in metal forming processes. Therefore, the interface friction has to be understood and controlled. For effective friction control, effects of the deformation process variables, such as deformation speed, material type, and lubrication, must be treated together to investigate interaction effects among these variables. There are several methods developed for quantitative evaluation of friction at the die/work piece interface in metal forming processes. Among all common methods for measuring the friction coefficient, the ring compression test has gained wide acceptance. This technique utilizes the dimensional changes of a test specimen to arrive at the magnitude of friction coefficient. For a given percentage of height reduction during compression tests, the corresponding measurement of the internal diameter of the test specimen provides a quantitative knowledge of the magnitude of the prevailing friction coefficient at the die/ Work piece interface. If the specimen's internal diameter increases during the deformation, friction is low; if the specimen's internal diameter decreases during the deformation, the friction is high. Using this relationship, specific curves, later called friction calibration curves, were generated by Male and Cockcroft relating the percentage reduction in the internal diameter of the test specimen to its reduction in height for varying degrees of the coefficient of friction. His results showed that the coefficient of friction tended to increase with an increasing deformation rate for different metal under dry condition and with a solid lubricant. Male and Cockcroft's standard ring geometry of 6:3:2 was used. The most accepted one is to define either a coefficient of friction, m , specifically; the Coulomb law of friction or the interface frictional shear factor, m , a value varies from zero for frictionless interface to one for sticking friction. Although neither of them has universal acceptance for general cases, one or the other approach may be useful for a

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Vol. 4, Issue 9, September 2015

particular case. Among all common methods for measuring the friction coefficient, the ring compression test has gained wide acceptance. It was originated by Kunogi and later improved and presented in a usable way by Male and Cockcroft. This technique utilizes the dimensional changes of a test specimen to arrive at the magnitude of friction coefficient. When a flat ring specimen is plastically compressed between two flat platens, increasing friction results in an inward flow of the material, while decreasing friction results in an outward flow of the material as schematically shown in Fig. 1.



If the specimen's internal diameter increases during the deformation, friction is low; if the specimen's internal diameter decreases during the deformation, the friction is high. Using this relationship friction calibration curves, were generated by Male and Cockcroft relating the percentage reduction in the internal diameter of the test specimen to its reduction in height for varying degrees of the coefficient of friction as shown in Fig. 2.

II. RING COMPRESSION TEST

- The method of free ring compression is the most widely applied method for determining contact conditions in bulk forming processes; therefore it is treated as the standard, universal method for determining factor of friction.
- Originally, it was conceived as the qualitative method for comparing the lubrication conditions to the influence of various lubricants onto the contact friction in cold extrusion processes, as prescribed by Kunogi in 1954.
- The method consists of monitoring the changes of inner diameter of the ring which is being compressed, because the changes are considered to be the representatives of the level of sensitivity to active contact friction.
- Friction factor is determined from these charts from the percent reduction in height and by measuring the percent change in the internal diameter of the specimen after compression.

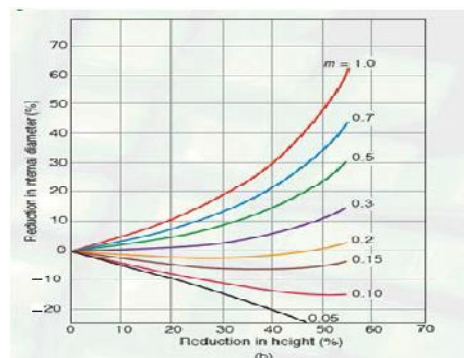


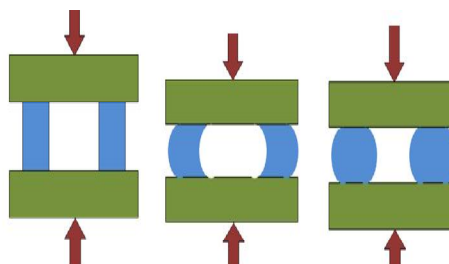
Fig.2 friction factor calibration curve

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Vol. 4, Issue 9, September 2015

- Graphic dependence between height strain and inner diameter strain, at various influences of friction, gives calibration curves for reading the value of coefficient / factor of friction.
- When a short, hollow cylinder is compressed axially between flat, parallel, rigid platens the diameter of the hole may either increase, decrease, or remain constant according to the amount of frictional constraint imposed by the platens.
- Under frictionless conditions the hole size increases proportionately to the outer diameter; and, the cylinder compresses as would the corresponding portion of a compressed solid cylinder.
- With increasing frictional constraint, the rate of expansion of the hole decreases and eventually the compressive hoop stress developed at the hole is sufficient to cause the hole to contract.
- This has the effect that the hole may initially increase in diameter and then contract. By suitably choosing the initial proportions of the cylinder, dimensional changes of the hole can thus provide a sensitive indication of the platen friction.
- Male and Cockcroft established the calibration curves by experimental method, assuming μ - friction in inter-contact of ring and tool. The initial dimensions of the ring in the following ratio, outer diameter: inner diameter: height = 6:3:2 were adopted as standard dimensions in ring test method.
- In this test, a ring specimen is compressed between the flat parallel tools and the coefficient of friction is determined on the basis of the change in the inner diameter of the ring using calibrated curve.
- Since this method does not require the determination of the load, it has been frequently used for estimating friction during forging without large expansion of a billet surface.



III. RESULT AND DISCUSSION

Since the metal forming induces high friction and heat generation at the interface between the tools and the work piece, interfacial friction has a significant effect on the forging applications, impacting die-wear, forming quality, and the deformation loads under both dry and lubricated conditions. The lubricity of lubricants is one of the most significant factors since it directly determines the interface friction, which in turn influences the stresses, the forging load, and the forging energy. In this study, the interface coefficient of friction and friction factor between the work piece and tools was determined under both dry and lubricated conditions.

The result obtained is as shown in the table. From the table it is clear that the interface friction can vary under different lubrication condition. The specimen having dimension as outer diameter 36mm, inner diameter 18mm and height 12mm, is used for the analysis but the dimension change occurred under the ring compression is different for the each lubrication condition.

The calibrated curve by the Male and Cockcroft of dimension ratio outer dia.: inner dia.: height (6: 3: 2) is used to determine the friction coefficient the result as follows,

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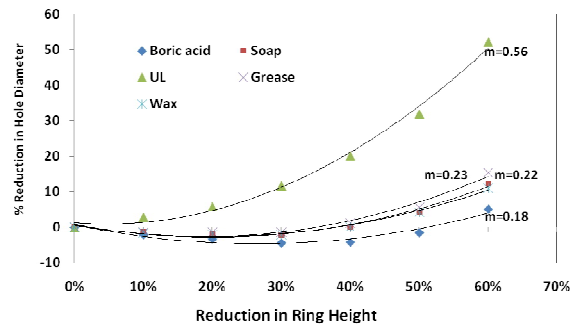
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Vol. 4, Issue 9, September 2015

IV. RESULTS & DISCUSSIONS ABOUT RING COMPRESSION TEST

Table.1 Friction co-efficient for instantaneous deformations of the ring.

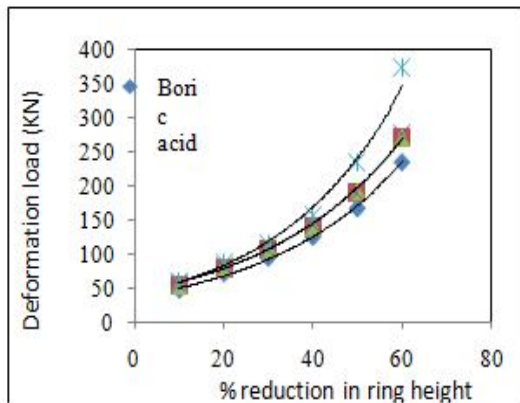
% reduction in height of the ring.	Co-efficient of friction = Diametric strain / strain in height.				
	boric acid	Grease	Wax	Soap	Ul
10.00%	-2	-1.33	-1.44	-1.34	2.83
20.00%	-3.33	-1.44	-1.88	-1.78	5.88
30.00%	-4.38	-1.38	-2.01	-2.11	11.66
40.00%	-4.16	1.11	0.11	0.11	20.16
50.00%	-1.5	5.61	4.22	4.12	31.83
60.00%	5.05	15.38	11.02	12.22	52.11



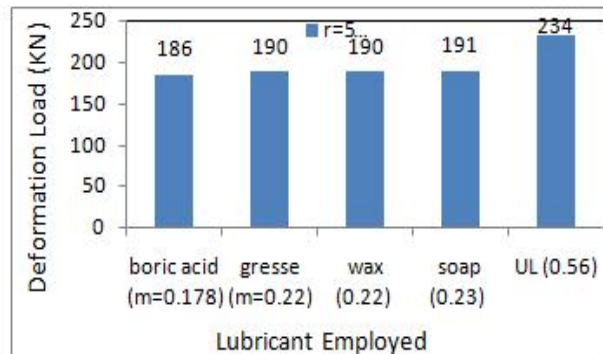
Male and Cockroft Calibration curves for estimating friction

Deformation load for different lubricants and height reductions

% reduction in height of the	Deformation load (KN)				
	Boric acid	Grease	Wax	Soap	Un lubricated
10	47	55	54	54	59
20	71	80	80	81	87
30	94	107	107	108	116
40	125	142	142	140	156
50	167	190	190	192	234
60	235	275	269	271	372



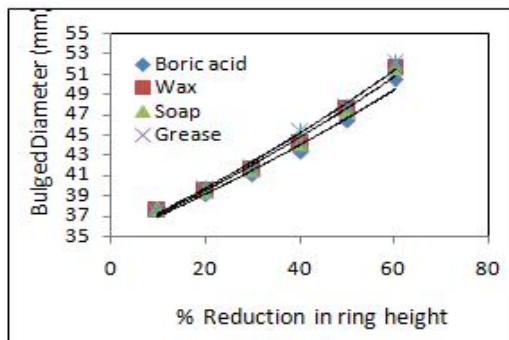
Deformation load Vs % height reduction of the ring for different lubricants



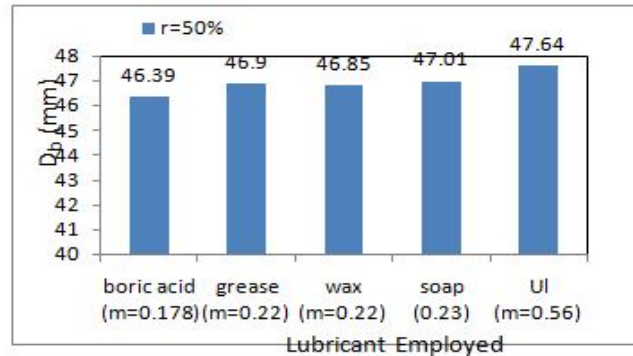
Deformation load vs Friction for 50% height reduction of the ring

Bulged diameters for different lubricants and height reductions

% reduction in height of the ring of the ring.	Bulged Diameter (D_b) in mm				
	Boric acid	Grease	Wax	Soap	Un lubricated
10	37.59	37.54	37.54	37.68	37.5
20	39.63	39.45	39.45	39.43	39.17
30	41.75	41.57	41.57	41.62	40.99
40	45.5	44.13	44.13	44.15	43.36
50	47.64	47.46	47.46	47.39	46.39
60	52.07	51.58	51.58	51.61	50.39



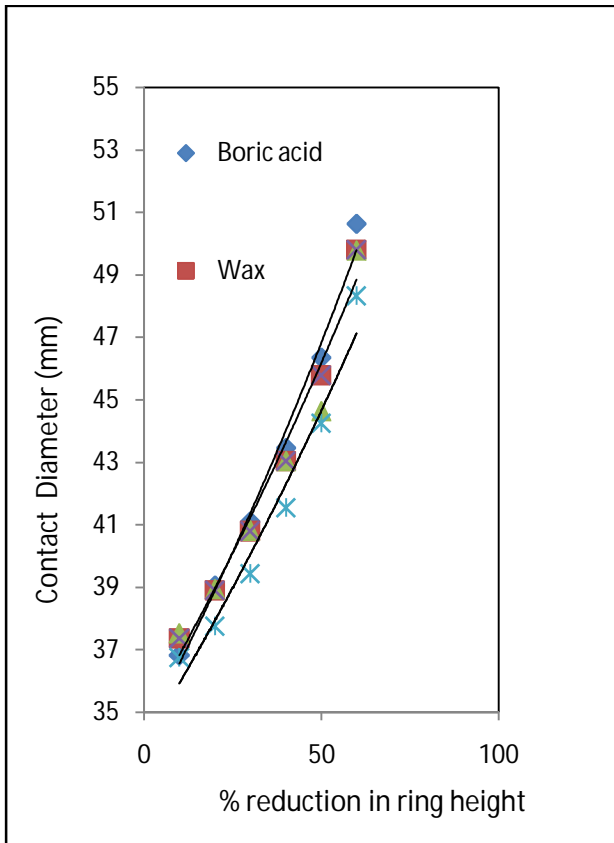
Bulged diameter Vs Height Reduction of The Rings



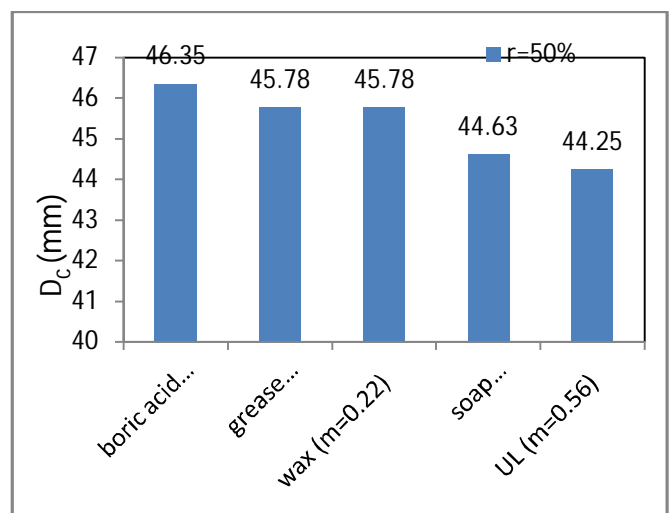
Bulged diameter for different lubricants at 50% reduction of the rings

Contact diameters for different lubricants and height reductions

% reduction in height of the ring.	Contact Diameter (Dc) in mm				
	Boric acid	Grease	Wax	Soap	Un lubricated
10	36.82	37.36	37.36	37.52	36.74
20	39.06	38.89	38.89	38.93	37.74
30	41.1	40.79	40.79	40.81	39.42
40	43.46	43.04	43.04	43.04	41.54
50	46.35	45.78	45.78	44.63	44.2
60	50.64	49.8	49.8	49.77	48.32



Contact diameter Vs different height reductions and different lubricants.



Contact diameter for different lubricants at 50% reduction of the ring

V. CONCLUSIONS

- Friction coefficient for several lubricants such as Boric acid, wax, grease and soap are determined as 0.18, 0.22, 0.22 and 0.23 and respectively.

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Vol. 4, Issue 9, September 2015

- The expansion of the ring hole was observed when Boric Acid was used as the lubricant indicating good lubrication and the contraction of the ring hole was examined under un lubricated condition.
- The load required for deformation when the billets are reduced to the same height is low in case of Boric Acid compared to the other lubricants.
- The barreling curvature was minimum when Boric Acid was applied as lubricant and maximum for un lubricated condition.
- The formability of the material was improved which lead to the better utilization of the material and processing conditions.

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5. P. Chandrasekhar et.al. found out that, the relative density of conical performs increases with increase in die velocity, forging load and perform height reduction and becomes comparable with corresponding wrought materials at the end of operation.
6. Syed Kamaluddinet.al. found out that, the friction factor m was found to be 0.3 and 0.6 under lubricated and dry conditions, respectively. The barreling profile fitted closely in a circular arc during compression loading.
7. S. Malayappan et.al Showed that, the different surface finishes such as grinding on the platens produce the low friction at the interface and hence the barreling is at a minimum. The rate of change of radius of curvature with respect to hydrostatic stress varies for different frictional conditions.
8. K. Manisekar et.al. concluded that, the relationship between the new hoop strain and axial strain conformed to a straight-line behavior. The relationship between calculated and the measured radius of curvature of the barrel conformed to a straight-line behavior with a net slop of 0.943.
9. R. Narayanasamy et.al. found out that, all the values of stress increase with the increase in approach angles of the billets into the dies under plane and tri-axial stress conditions. A straight-line behavior is observed between the hoop strain and the axial strain with the slope of 1.0 irrespective of approach angles and initial protrusion heights.
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