# Evaluation of Compression Behavior of Aluminum Alloy (AA2219)

Dr. S. Devaki Rani
*Department of Metallurgical Engineering*
*JNTUH, CEH, Hyderabad.*

K. Srinivasa Rao
*Department of Metallurgical Engineering*
*Govt. Polytechnic, Ramanthapur, Hyderabad.*

**Abstract: Aluminum alloys are widely used due to their strength and light in weight. AA2219 alloy is having wide applications in automobile sector and aerospace industries. The alloy in hexagonal shape is cold compresses at different loads and the effect of bulging with and without using lubricants is studied. Effect of ageing treatment is investigated and the evolution of microstructures is studied. AA2219 alloy withstands more compressive load. The microstructure shows formation of sub grains when bulged 45% and 60% of the breaking load but it is not formed in case of 80% breaking load. The grain size becomes coarser from 80% to 45% of breaking loads as seen in the microstructures. The present study reveals that more than 60% of deformation load is essential to get fully uniformly deformed microstructure.**

**Key Words – Ageing, Aluminum alloy, Bulging, Compressive loading**

## I. INTRODUCTION

A wide variety of metals and alloys are being used worldwide for a large number of applications depending upon their characteristics and properties. These materials before being used in any specific operations need to be tested out for the various parameters pertaining to them. Determination of the load to carry out these operations is of paramount importance. Load depends on the flow stress of materials besides the geometry of the die and friction at the tool-work piece interface. Towards this end, bulging test at different temperatures more commonly known as compression tests need to be conducted for a wide range of strain rates and temperatures... When compressive load is applied on a particular specimen, the deformation may be elastic or plastic shortening as in the case of ductile materials, crushing and fracture in brittle materials, or a sudden bending deformation called buckling in long, slender bars, or a combination of these. Schey et al presented a comprehensive report on the different geometrical factors that affect the shape of the barrel [1]. Banerjee and Narayanasamy et al. showed theoretically that the barrel radius can also be expressed as a function of axial strain and subsequently confirmed the same through experimental verification [2]. Yang et al. developed an upper bound solution for determination of forging load and also deformed bulged profile during upset forging of cylindrical billets under the dissimilar frictional conditions at flat die surfaces [3]. Kulkarni and Kalpakjian having examined the arc of barrel, led an assumption that it may be circular or parabolic [4]. Gokler et al. made a study of taper upset forging using elastic plastic finite element analysis [5]. Malayappan and Narayanasamy studied the effect of barreling during cold upsetting of solid cylinder with the introduction of conical die constraint at one end at both ends of the work-piece in unlubricated as well as lubricated conditions [6]. They also have experimentally studied the barreling phenomenon under varying frictional conditions at the flat die surface and with the introduction of an extrusion die constraint at one end of the work-piece

### *A. Aim of Work*

Compression tests are basically performed to understand and properly predict the flow behavior of different specimens by establishing a relationship between flow stress, strain, strain rate and temperature. The present work consists of investigation of aluminum alloy under compressive loads and micro structural characterization after heat-treatment. The study revealed that at what percentage of compressive load a uniformly deformed specimen is obtained with better mechanical properties.

## II. EXPERIMENTAL WORK:

The cast aluminum alloy billets obtained were cut into standard sizes [Fig. 1 (a)]. The composition of the alloy is given in the Table 1. The raw aluminum sample is in the form of a solid cylinder having a diameter of 30 mm and a length of 250 mm. Five specimens of length 33 mm(approx.) each and a hexagonal edge length of 12 mm(approx.) were obtained by using lathe and milling machines [Fig.1 (b)]. Two samples were tested with and without lubricant oil till the ultimate load was applied. The rest of the three samples were reduced by 80%, 60% and 45% of the ultimate tensile load. All the five samples were cut into three pieces and subjected to heat treatment process. The heat treatment consists of solution treatment at 470°C and aged at 120°C for 6 hours. The microstructures were observed for solution treated and aged samples.

Table 1: Chemical Composition of AA2219 Aluminum alloy

| Element | Si | Fe | Cu | Mn | Mg | Zn | V | Ti | Zr | Al |
|---|---|---|---|---|---|---|---|---|---|---|
| % | 0.2 | 0.30 | 5.8 to 6.8 | 0.3 to 0.4 | 0.02 | 0.1 | 0.05 to 0.15 | 0.02 to 0.1 | 0.10 to 0.25 | Rest |


Figure 1: (a) Aluminum alloy cast billet (b) Aluminum alloy section pieces

## III. RESULTS AND DISCUSSION

The compression data obtained for sample AA2219 in transverse direction sample is shown in Table 2

Table 2: The compression data obtained for sample AA2219 transverse direction sample

| Specimen | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Deformation starting load (Tons) | 12.08 | 12.85 | | | |
| Crack initiation load (Tons) | 27.30 | 34.40 | | | |
| Ultimate load (Tons) | 27.70 | 29.40 | | | |
| Change in diameter after bulging (mm) | 32.22 | 36.16 | 30.60 | 26.44 | 25.44 |

<u>AA2219 Specimen Details</u>:
Specimen 1: Transverse test sample Load applied without oil
Specimen 2: Transverse test sample Load applied with oil
Specimen 3: Transverse l test sample Load applied 80% of ultimate load
Specimen 4: Transverse test sample Load applied 60% of ultimate load
Specimen 5: Transverse l test sample Load applied 45% of ultimate load

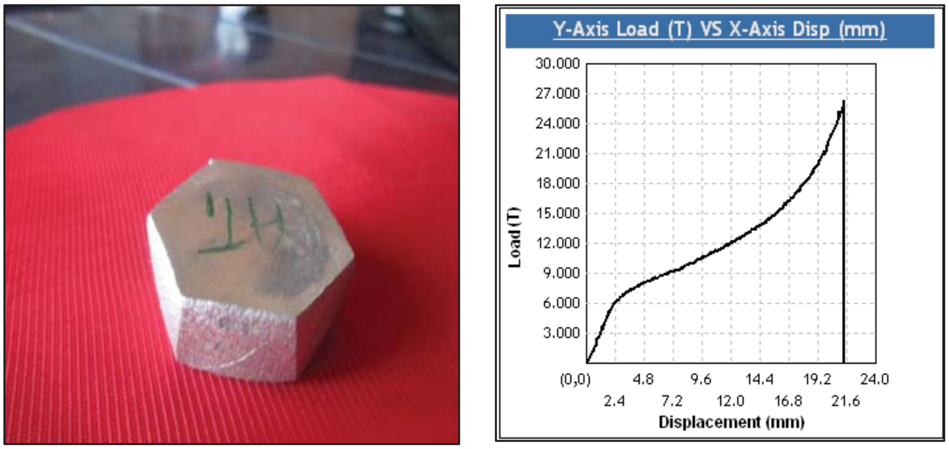


Figure 2: Deformed Transverse Specimen of AA2219 Load applied without oil

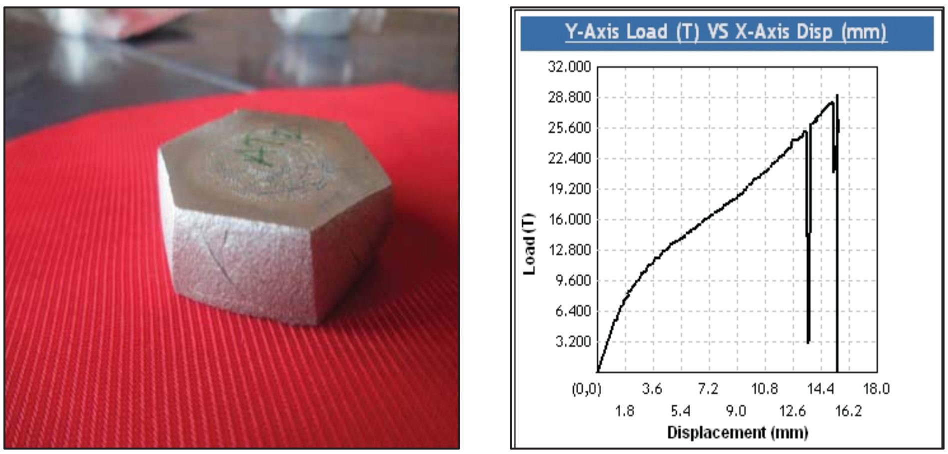


Figure 3: Deformed Transverse Specimen of AA2219 Load applied with oil

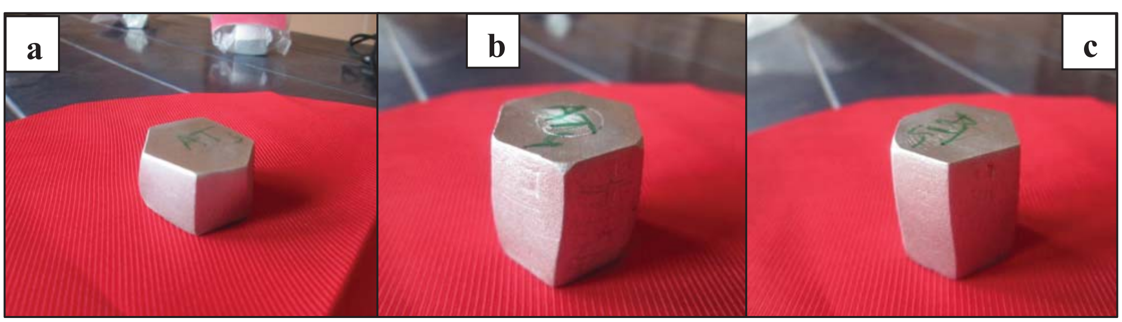


Figure 4: Deformed Specimen with (a) 80% (b) 60% (c) 45% of breaking load applied

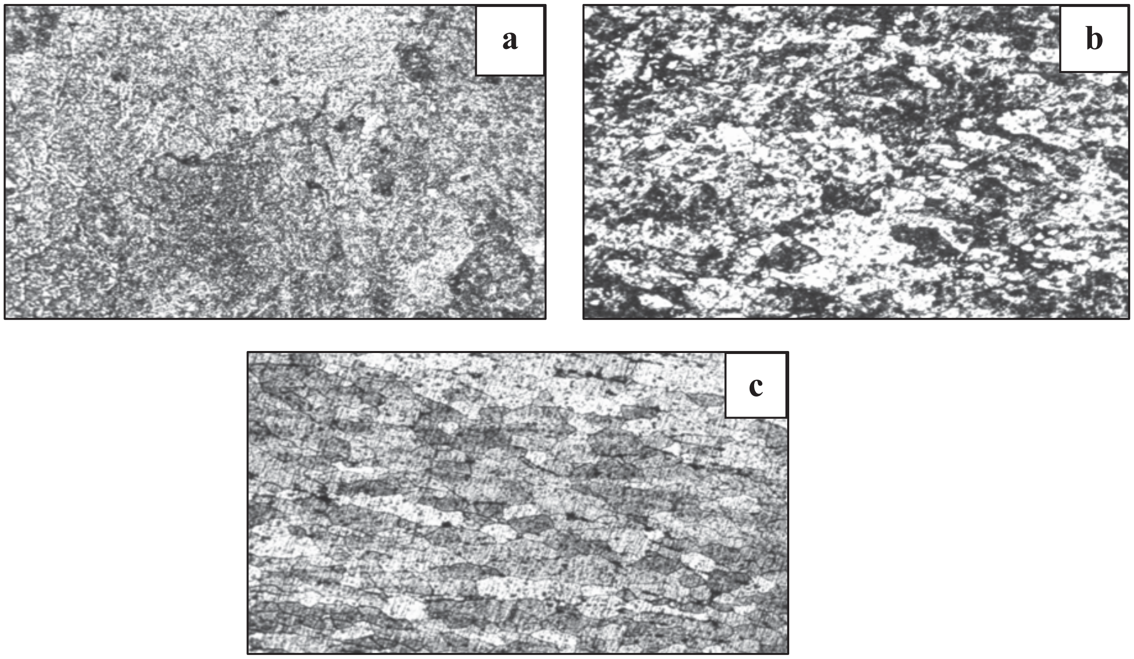


Figure 5: Microstructures of specimens without oil at 100X
(a) As bulged (b) As bulged+ solution treated (c) As bulged+ solution treated + aged

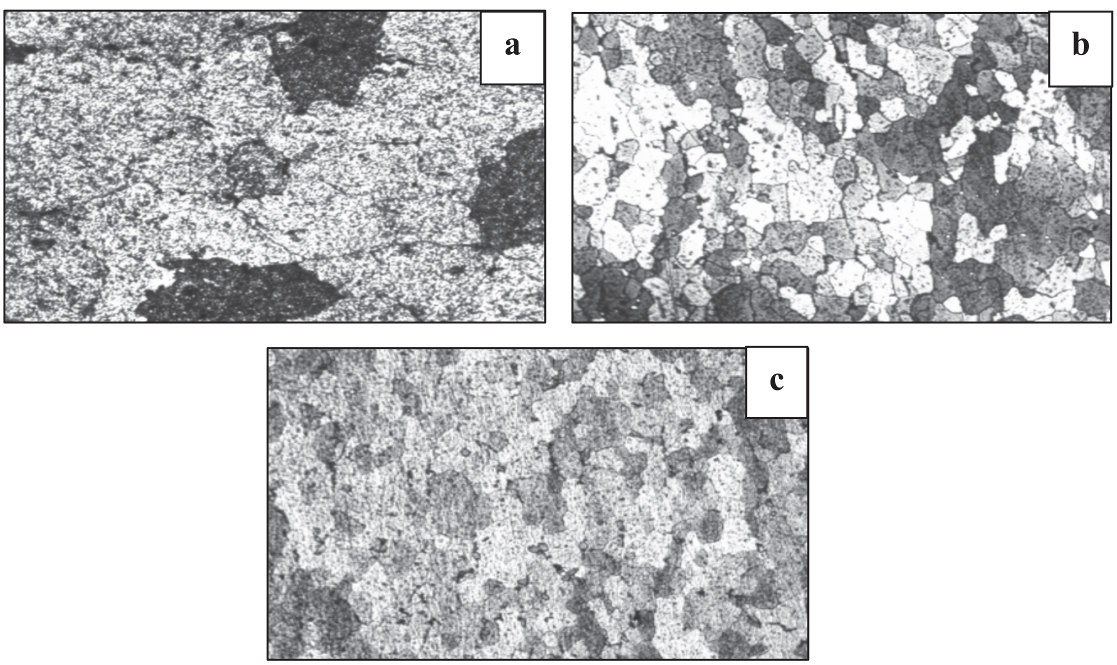


Figure 6: Microstructures of specimens with oil at 100X
(a) As bulged (b) As bulged+ solution treated (c) As bulged+ solution treated + aged

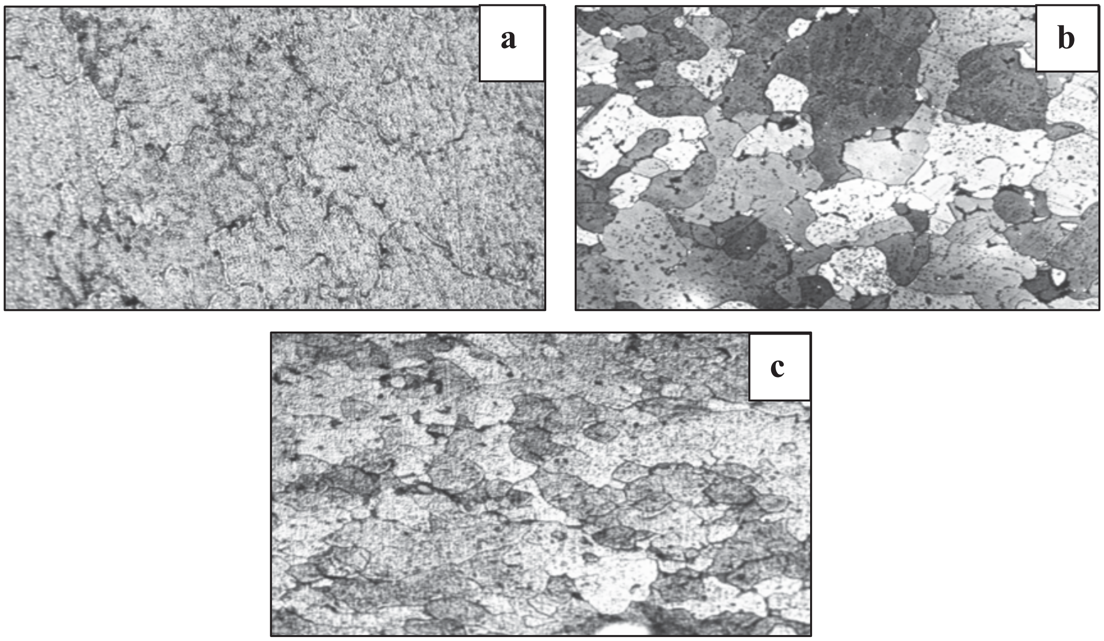


Figure 7: Microstructures of specimens after applying 80% of breaking load at 100X
(a) As bulged (b) As bulged+ solution treated (c)As bulged+ solution treated + aged

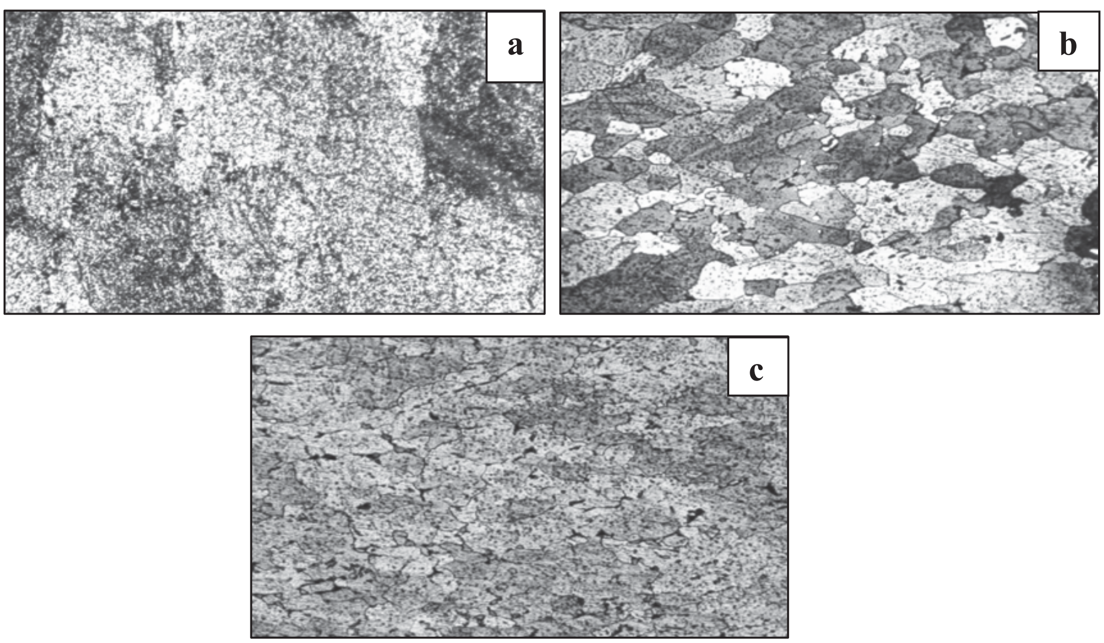


Figure 8: Microstructures of specimens after applying 60% of breaking load at 100X
(a) As bulged (b) As bulged+ solution treated (c) As bulged+ solution treated + aged

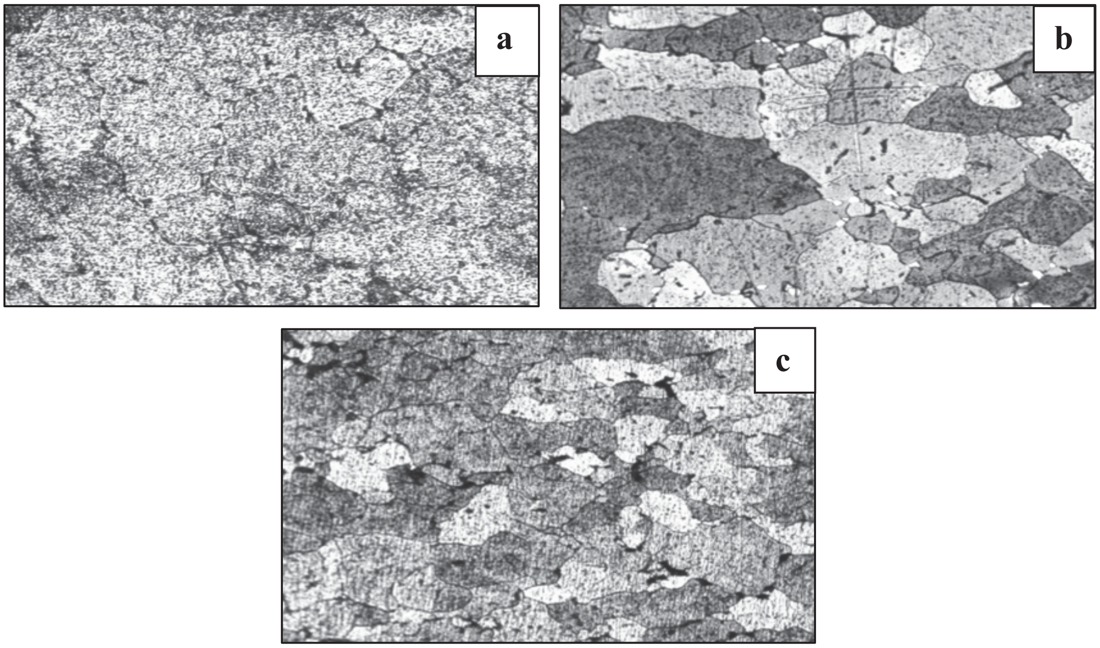


Figure 9: Microstructures of specimens after applying 45% of breaking load at 100X
(a) As bulged (b) As bulged+ solution treated (c) As bulged+ solution treated + aged

From Table 2 it is observed that by applying lubricant it is possible to absorb more than one ton of load for specimen 2T tested in transverse direction. The absorbing of one ton of load more is seen in Fig.2 and Fig. 3 through the graphs obtained from UTM in case of specimen 2T. This is due to that the lubricant spreads on the surface of specimen and the layer of lubricant gives some resistance to breakage. After applying 80%, 60%and 45% of the ultimate load the percentage of reduction in height is increasing as shown in Fig. 4 (a) to (c). The microstructures of Fig. 5(a- c) show transverse specimens of bulged, bulged and solution treated and bulged+ solution treated and aged samples respectively without applying lubricant in case of specimen 3,4 and5. It shows that more elongation of grains takes place during bulging. The aged sample microstructure shows fine grains and alloy precipitates in the elongated grain boundaries. There is no sub grains formation in this condition. The microstructures of Fig. 6 (a -c) show bulged, bulged and solution treated and bulged+ solution treated and aged respectively with applying lubricant. Compared to the microstructure of specimen1T without applying oil it is observed that more elongation of grains takes place as well as different grain boundaries are forming after aging. The microstructures of Fig. 7 (a-c), Fig. 8 (a-c) and Fig. 9 (a-c) shows 80%, 60% and 45% of breaking loads with bulged, bulged and solution treated, bulged+ solution treated and aged samples respectively for samples3T, 4T and 5T tested in transverse direction. The sample loaded with 80% of breaking load show uniformly deformed microstructure as shown in Fig. 7 (c).

## IV. CONCLUSIONS

This alloy has exhibited more inherent structural strength to take more load with oil for deformation. The deformed grain structure either with oil or without oil is more uniform both in case and in core. The aged microstructure of the sample having 80% of the compressive load, shows no sub grains where as in the case of the sample having 60% and 45% of the compressive load the sub grains formation can be seen. More than 60% of deformation load is essential to get fully uniform deformed microstructure.

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