Effect of Cold Deformation in AA2219 Aluminum Alloy

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Abstract:-Aluminium alloy AA2219 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:

Investigations on cold upset forging of solid cylindrical specimens have been carried out by many investigators. Comprehensive review of literature has been published by Johnson and Mellor [1]. Another major aspect of axi-symmetric compression from the standpoint of testing the mechanical manufacturing properties of metals is its estimation of their forming limits up to plastic instability and subsequently fractures. In upsetting the presence of frictional constrains between the dies and the work-piece has a direct effect on the plastic deformation of the later. When a solid cylinder undergoes axial compression between the punch and bottom platen, the work-piece material which is in contact with the surfaces undergoes heterogeneous deformation which results in the "barreling" of the cylinder. Friction at the faces of contact causes a retarding effect on the plastic flow of metal on the surface and in its vicinity. As a result, a conical wedge of a relatively unreformed metal is formed directly below it while the rest of the cylinder suffers high strains and bulges out in the form of a barrel. This demonstrates that the metal goes easily towards the nearest free surface which is said as the point of least resistance, a well-known principle of plastic deformation. However, the use of lubricants greatly reduces the degree of bulging and under the condition of proper lubrication, bulging can be brought down to zero. However, the friction cannot be eliminated during upset forging and it is extremely necessary to go for a correction factor for the bulging during the design of a die. Kulkarni and Kalpakjian [2] having examined the arc of barrel, led an assumption that it may be circular or parabolic. In the meantime, Schey et al [3] presented a comprehensive report on the different geometrical factors that affect the shape of the barrel . Yang et al. [4] 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. Gokler et al. [5] made a study of taper upset forging using elastic plastic finite element analysis. Narayanasamy and Pandey [6] studied the effect of barreling in aluminium solid cylinders during cold upsetting. Malayappan and Narayanasamy [7] studied the effect of barreling during cold upsetting of solid cylinder with the introduction of conical die constraint at one end and at both ends of the work-piece in unlubricated and as well as lubricated conditions.

- **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 aluminium alloy billets obtained were cut into standard sizes [Fig. 1 (a)]. The composition of the alloy is given in the Table 1. The raw aluminium 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.

Fig. 1(a): Aluminium alloy cast billet (b) Aluminium alloy section pieces

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

III. RESULTS & DISCUSSIONS:

The compression data obtained for sample AA2219 in longitudinal direction sample is shown in Table 4.1

Table 2: Compression data obtained for AA2219 alloy in longitudinal direction

	Specimen 1L	Specimen 2L	Specimen 3L	Specimen 4L	Specimen 5L
Deformation starting load (Tons)	11.25	12.23			
Crack initiation load (Tons)	35.10	36.20			
Ultimate load (Tons)	36.30	38.00			
Change in diameter after bulging (mm)	36.32	36.52	32.68	29.13	25.87

Specimen 1L: Longitudinal test sample Load applied without oil
Specimen 2L: Longitudinal test sample Load applied with oil
Specimen 3L: Longitudinal test sample Load applied 80% of ultimate load
Specimen 4L: Longitudinal test sample Load applied 60% of ultimate load
Specimen 5L: Longitudinal test sample Load applied 45% of ultimate load

Fig. 2 (a) and Fig. 2 (b) shows deformed specimens of AA2219 breaking load applied with out lubricant and with lubricant

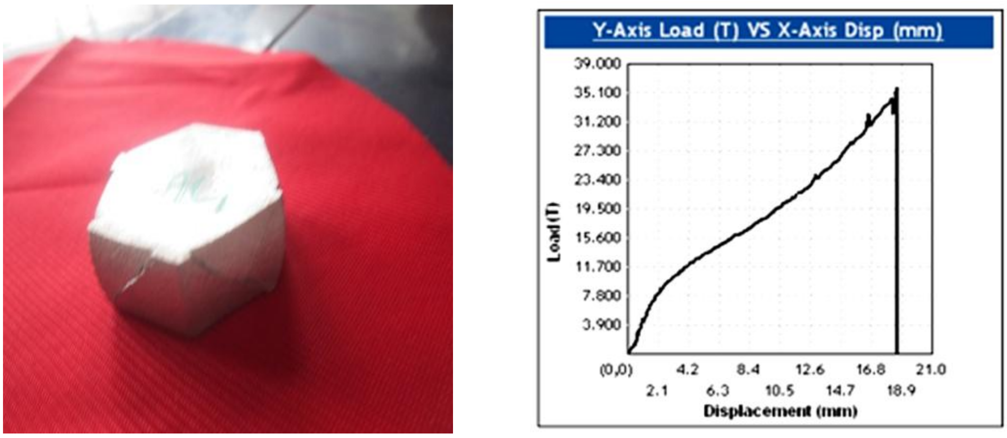

Fig. 2 (a): Deformed Specimen (without oil)

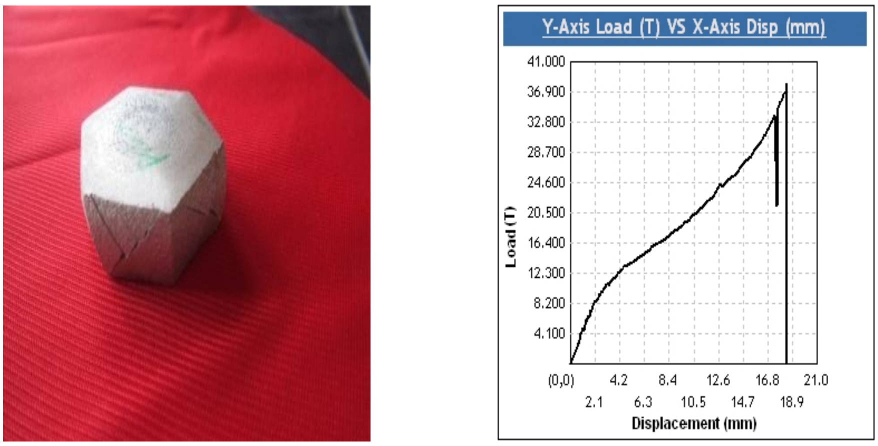

Fig. 2(b): Deformed specimen (with oil)

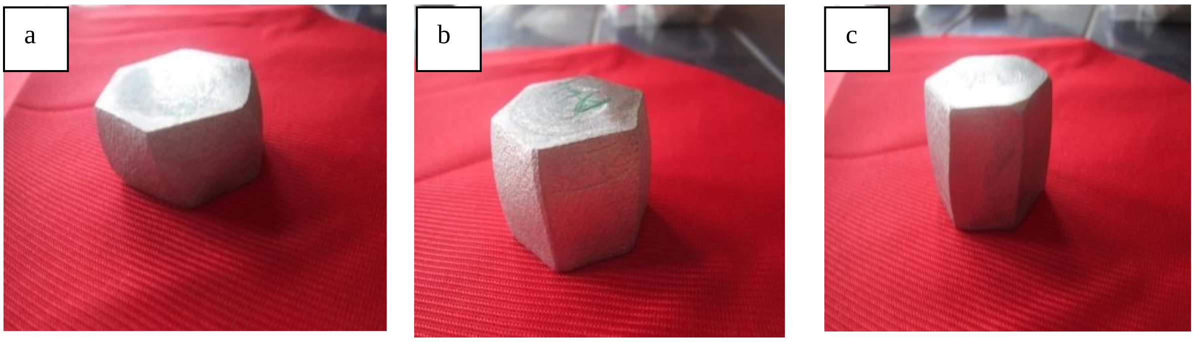

Fig. 3: Deformed Specimen (a) with 80% of breaking load applied (b) with 60% of breaking load applied (c) with 45% of breaking load applied

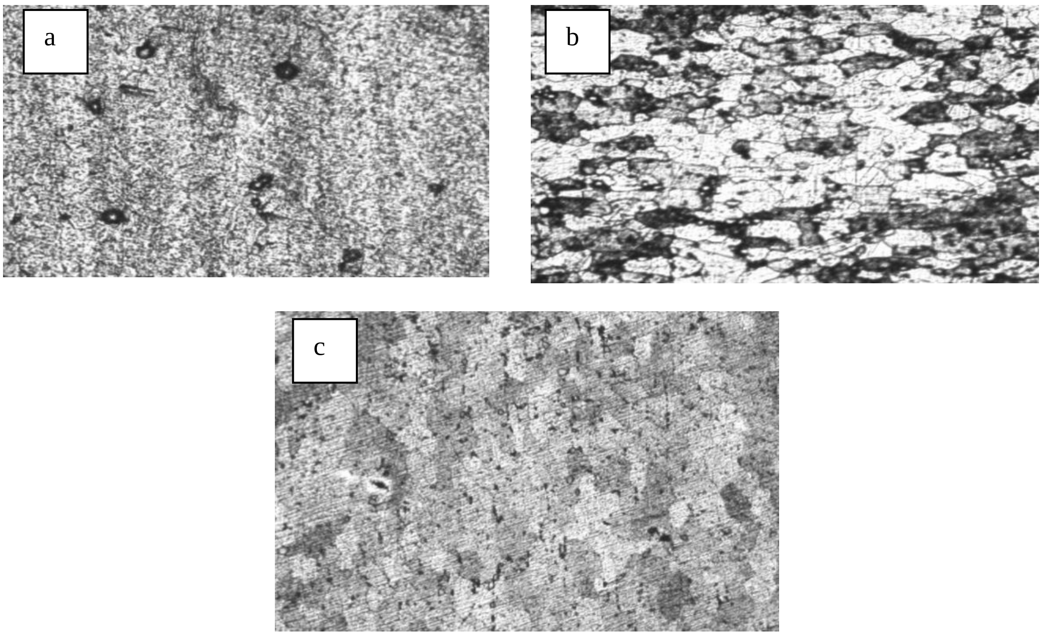

Fig. 4: Microstructures of specimens without oil at 100X
(a) As bulged (b) As bulged+ solution treated (c) As bulged+ solution treated+ aged

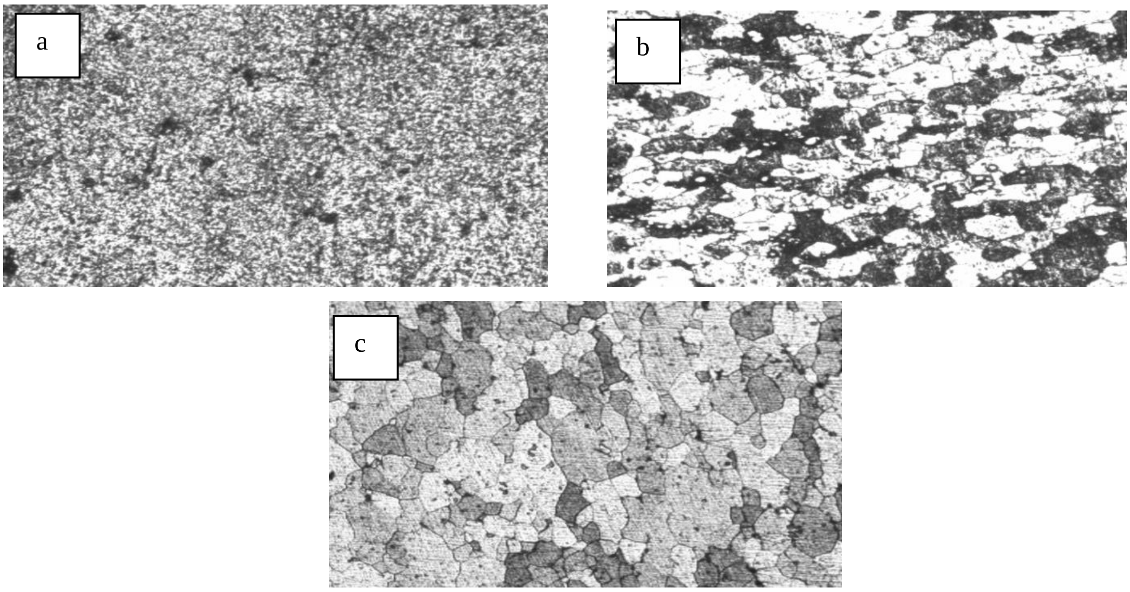

Fig. 5: Microstructures of specimens after bulging with oil at 100X
(a) As bulged (b) As bulged+ solution treated (c) As bulged+ solution treated +aged

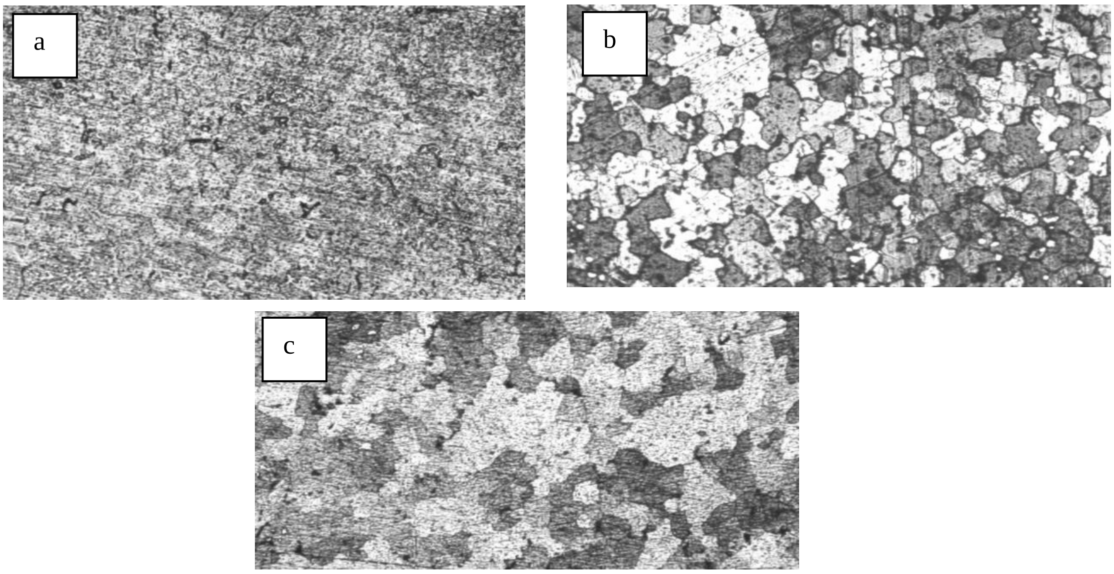

Fig. 6: Microstructures of specimens after bulging applied 80% of breaking load at 100X
(a) As bulged (b) As bulged+ solution treated (c) As bulged+ solution treated +aged

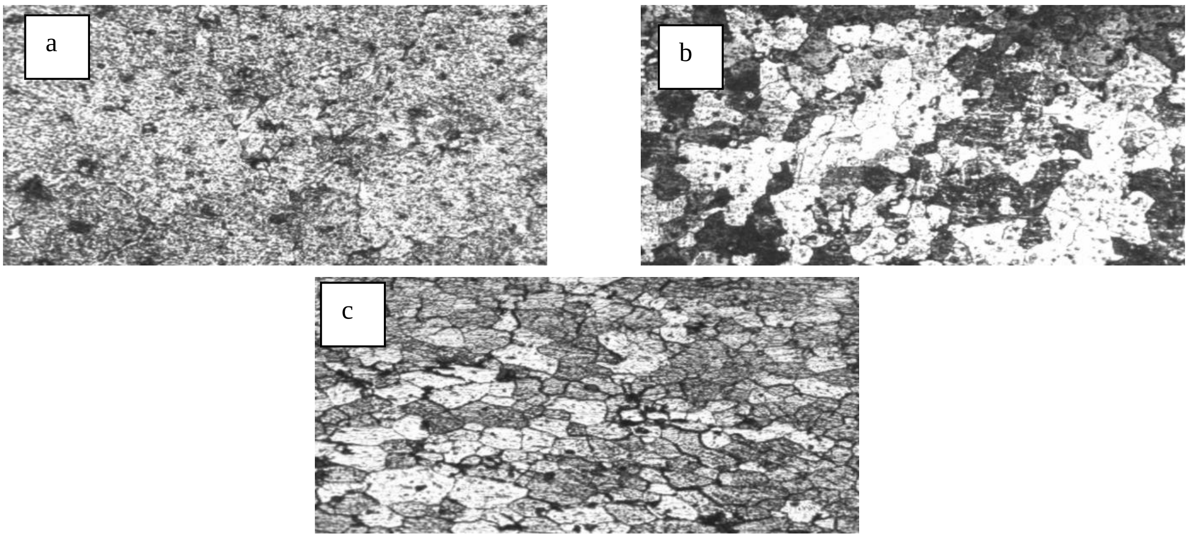

Fig. 7: Microstructures of specimens after bulging applied 60% of breaking load at 100X
(a) As bulged (b) As bulged+ solution treated (c) As bulged+ solution treated +aged

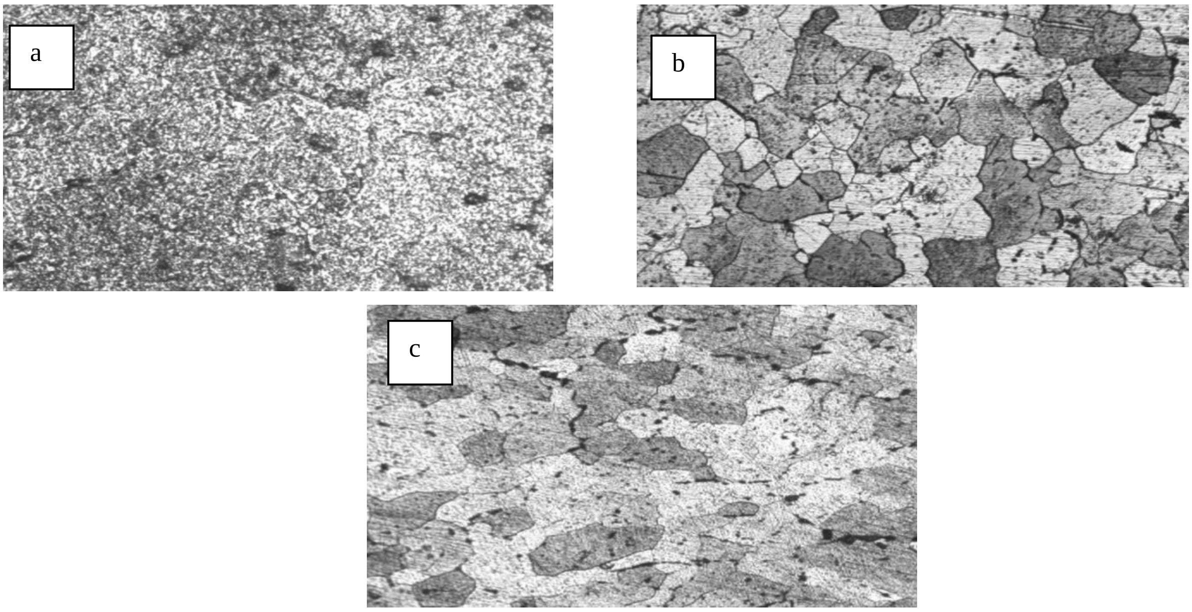

Fig. 8: Microstructures of specimens after bulging applied 45% of breaking load at 100X
(a) As bulged (b) As bulged+ solution treated (c) As bulged+ solution treated +aged

From table 2 it is observed that by applying lubricant it is possible to absorb more than one ton of load for specimen 2L . The absorbing of one ton more seen in Fig. 2 (a) and 2 (b) through the graphs obtained from UTM in case of specimen 2L.This is due to the fact that the lubricant spreads uniformly on the surface of specimen and offers some resistance to breakage. After applying 80%, 60% and 45% of the ultimate load the percentage of reduction in height is increased as shown in Fig. 3(a) to 3 (c).

The microstructures of Fig. 4 (a- c) show bulged, bulged and solution treated and bulged+ solution treated and aged samples respectively without applying lubricant in case of specimen 3L,4L and 5L. It shows that the grains are elongated during bulging and some precipitates are formed in sub grains during solution treatment as seen in Fig. 4 (b). 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. 5 (a -c) show bulged, bulged and solution treated and bulged+ solution treated and aged respectively with applying lubricant. Compared to the microstructure of specimen 1L without applying oil it is observed that less elongation of grains takes place as well as fixed grain boundaries are forming after aging.

The microstructures of Fig. 6 (a-c), Fig. 7 (a-c) and Fig. 8 (a-c) shows 80%,60%and 45% of breaking loads with bulged , bulged and solution treated ,bulged+ solution treated and aged samples respectively for samples3L, 4L and 5L. The sample loaded with 80% of breaking load show uniformly deformed microstructure as shown in Fig. 6 (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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