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Research Article

Evaluation of Mechanical Properties of Aluminium Alloy AA 6061(HE-20)

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Abstract

The general manufacturing objective during the fabrication of automotive, structural and aerospace components, particularly through flow forming process is to achieve predefined product quality characteristics and mechanical properties with process cost and time constraints. The current state of the economy and the consequent market pressure has forced vehicle manufacturers to simultaneously reduce operating expenses along with further improving product quality. With light weight and high performance characteristics Aluminium alloy acts as an important material in defence and aerospace applications. The Mechanical Properties of Aluminium Alloy AA 6061(HE-20) were evaluated and compression test was conducted on the material under annealed condition. Aluminium alloys have attractive properties of high corrosion resistance and excellent machining properties. The micro hardness, microstructure and mechanical properties like hardness, ultimate tensile strength, yield strength, Strength Coefficient(K), Strain hardening coefficient (n) and % reduction at fracture of Aluminium Alloy AA 6061(HE-20) were evaluated before the flow forming process, so that these values can be compared after flow forming process. It was observed that Manganese content which controlled the grain structure was slightly high, which results in superior strength. From the microstructure it was revealed that the grain size was uniformly distributed in all the directions.

Keywords: *AA6061, Compression test, Strength coefficient, Strain hardening exponent, Micro hardness.*

1. Introduction

Aluminium is the second most abundant metallic and structural element in the earth's crust. It is mostly extracted by the chemical refinement of bauxite using the Bayer process to form Aluminium oxide (alumina) from which (99.9% pure) Aluminium extracted by the Hall-Heroult method. It is commercially available as wrought or cast in the form of ingots, bars, sheets, etc. The oxide layer formed on freshly machined Aluminium insulates it against further environmental attack thus providing good corrosion resistance. It has good electrical and thermal conductivities as well as good ductility and malleability. Aluminium is widely used in the food and chemical industry, in metallurgical applications, the electrical industry, for structural applications, cryogenic applications, etc., and of course extensively in the transportation industry and pollution has strongly influenced the exploration of lightweight materials within the automotive industry. Aluminium Alloy AA 6061(HE-20) is increasingly becoming a new class of material in aerospace applications because, their properties can be tailored through the addition of selected reinforcements. (Hamouda, *et al*, 2007 and Sudarshan, *et al*, 2008*)*. In particular, particulate reinforced MMCs have recently found special interest because of their specific strength and specific stiffness at room and elevated temperatures (Mohammad Sharifi, *et al*, 2011). Applications of Aluminium-based MMCs have increased in recent years as engineering materials. The mechanical properties of composites are evaluated (Madhu Kumar , *et al*, 2012) and also the properties of Aluminium alloys for automobile applications are evaluated (Morita, 1998). Another important parameter, surface finish, has been optimized by response surface method (Kadirgama, *et al*, 2008) and also developed surface finish prediction model (Kadirgama , *et al*, 2008). Hand books (Davis and Ducker Worldwide , 2008) were used extensively.

2. Material

Aluminium alloy (6061) whose chemical composition is listed in Table 1. It was annealed at a temperature of 550°C for two hours to take the precipitation into solution and quenched in water to retain solute in solution.

Table.1 Chemical composition of Aluminium Alloy 6061 (HE-20)

Cu	Si	Mg	Fe	Mn	Cr	Zn	Ti
0.24	0.64	0.88	0.16	0.17	0.16	0.05	0.01

The sample taken has been tested and it is in agreement with AA6061 (HE-20) specifications except for

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Manganese which is slightly high. Addition of manganese controls the grain structure, which results in superior strength. The specimen is tested for its strength on UTM and the results of which are shown in Table 2.

Table 2 Mechanical properties of Aluminium Alloy 6061

Young's Modulus	5 GPa
Poisson's ratio	0.33
Density (kg/m3)	2700
UTS	296.4 MPa
Strength Coefficient	562.5
Strain hardness (n)	0.5487
Yield Strength	155 MPa
% reduction at fracture	45.8

(HE-20) during compression test.

3. Experimental Procedure

The forged Aluminium alloy AA 6061 rod hot-rolled and annealed was used. Table 1 shows the chemical composition of the present 6061 alloy. Al alloy was used in the form of ingots. The cleaned metal ingots were melted to the desired temperature of 740°C. Cover flux was added in to the molten metal in order to minimize the oxidation. Electrical resistance furnace with temperature controlling device was used for melting.

Table 2 Mechanical properties of Aluminium Alloy 6061 (HE-20) during compression test.

Fig.1 Universal Testing Machine (UTM) UTB3103

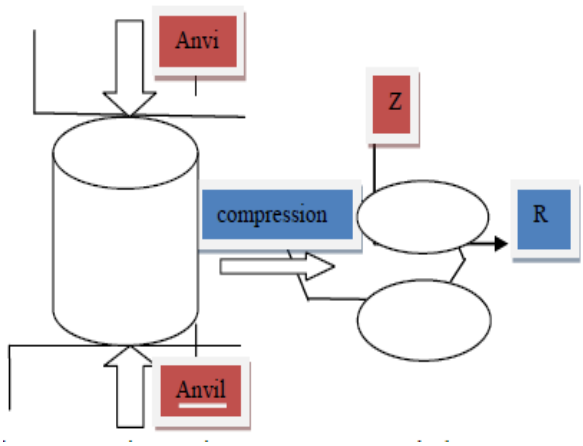

Fig.2 Compression Specimen as per ASTM standard

Fig.3 a) Before compression b) After compression

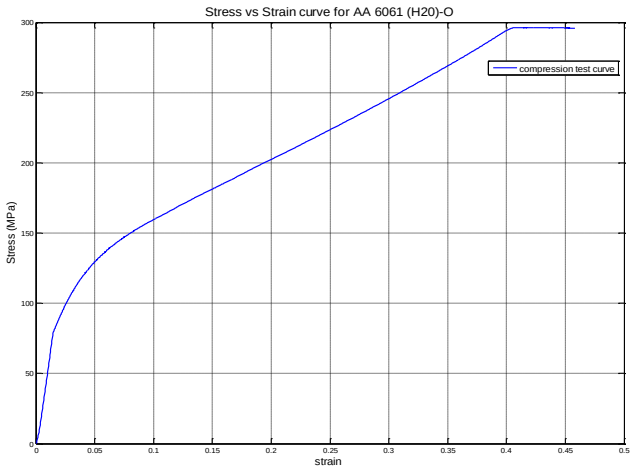

Fig.4 Stress and strain curve

The figure 3 shows compression properties of the alloy which were determined by performing the compression test on standard cylindrical compression specimens of Aluminium alloy (AA 6061**)**

The figure 4 shows that the Stress and Strain curve for Aluminium alloy under the compression test.

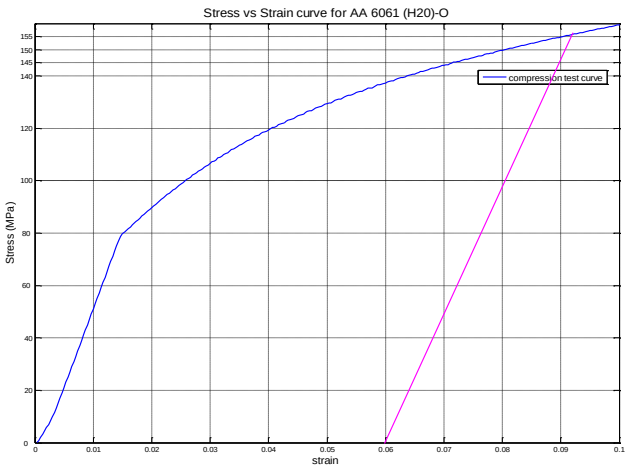

Fig.5 Stress and strain curve

The figure 5 shows that the Yield strength calculation by offset method by 0.2% of gauge length. In this test the specimen dimensions are 30mm gauge length and 20mm diameter. From the above procedure the Properties of Aluminium alloy AA6061 were obtained and listed in Table.3.

Table.3 Mechanical properties of Aluminium Alloy 6061 (HE-20) during compression test

Young's Modulus	5GPa
Poisson's ratio	0.33
Density (kg/m3)	2700
UTS	296.4 MPa
Yield Strength	155 MPa
% reduction @ fracture	45.8

And also from the Figure. 4, the strength coefficient and strain hardening exponent were calculated, considering number of points on the curve.

3.2 Hardness testing

Micro hardness was calculated by using Micro-hardness Vicker's testing machine. A precision diamond indenter is impressed on material at a load of 100 gf for 15 secs. Six indentations were done at multiple locations to ensure repeatability of results. In order to avoid the segregation effect of the particles, six readings were taken for each sampe and the repeatability value 66.35-68.63(HV) is reported.

The optical photomicrographs of the AA6061are shown in Fig. 6. It is observed from the figure grain size reticule, conforming to ASTME-112 standard was used for manual measurements were also done using Image analysis software to verify the obtained results.

4. Results and Discussions

4.1. Evaluation of microstructure

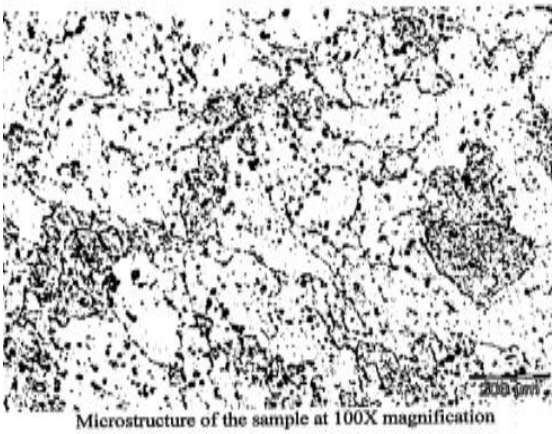

Fig.6 Photomicrographs of the Al6061–200μm particulate at 100 xs

4.2. Evaluation of compression strength Coefficient and Strain hardness

From the Fig. 4 evaluation of compression strength Coefficient and Strain hardness values were obtained from the flow rule and shown in Table 5.

Flow rule is given as $\sigma = K \varepsilon^n$

where σ : true stress

ε : true strain

n : strain hardening exponent

K : Strength coefficient

Table 4 Strength Coefficient and Strain hardness values of Aluminium alloy

Strength Coefficient(K)	562.5
Strain hardness (n)	0.5487

5. Conclusions

The compression test was conducted on Aluminium alloy on UTM UTB3103 at room temperature. The samples were prepared according to ASTM E9. The compression properties of the alloy were determined by performing the compression test on standard cylindrical compression specimens.

Mechanical properties required for flow forming of this material has been evaluated by conducting compression test.

The strength coefficient and strain hardening coefficient are found to be 562.5 and 0.5487 respectively. The micro hardness of the Aluminium alloy six indentations were done at multiple locations to ensure repeatability of results. In order to avoid the segregation effect of the particles, six readings were taken for each sample and the repeatability value is reported. Micro hardness obtained was 66.35-68.63(HV).

Microstructural observations shows that the grain sizes are uniformly distributed in the Al6061 alloy.

These results will enable us to determine the force (pressure) to be given on the rollers for flow forming. The force on the roller decides the feed rate and percentage of reduction.

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