International Journal of Multidisciplinary and Current Research

Research Article

ISSN: 2321-3124
Available at: http://ijmcr.com

Hardness of AL-6063 Thixoformed at Different Temperatures

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Accepted 04 May April 2015, Available online 06 May 2015, **Vol.3 (May/June 2015 issue)**

Abstract

The Thixoforming process is a new method for manufacturing complicated and net shape component through which high strength materials can be formed more easily. The high mechanical, geometric and surface quality of components produced through Thixoforming can justify the removal of additional production processes such as machining steps and the need for reinforcing inserts. In this study Al alloy 6063 which has low extrude ability has been thixoformed by the extrusion process. In this research the effect of Thixoforming with one step, three step induction heating regimes for the temperature range (540 to 580°C) at same die material and same ram speed were investigated. It was found that the mean value of Rockwell hardness of Al- 6063 alloy at 545°C was found 9 HRC and at 560°C was 8 HRC. Also the mean value of Brinell hardness of Al- 6063 alloy at 545°C was found 88 HBW and at 560°C was 82 HBW.

Keywords: *Thixoforming process, Hardness etc.*

1. Introduction

In Thixoforming process material is injected into component die at semi-solid state. In order to get the better microstructure (grain refinement) and better thixotropic behavior of the material (viscosity decreases with increase of shear stress). Thus the material which is to be injected into component die is first heated at suitable temperature so its structure which is in tree dendrites shape is change in spheroidal shape during solidification.

For more than 60-years existence of extrusion technologies a wide variety of machine designs for their realization has appeared. Extrusion is short-time high-temperature process which is success fully applied both in food and feed mill industries. The operation principle of extruders is determined by the technological essence of an extrusion process. Extrusion is a complex physico-chemical process which goes under the influence of mechanical force, moisture and high-temperature. The processed product is heated up due to the transformation of mechanical energy into heat which is escaped at overcoming an internal friction and plastic deformation of the product or due to external heating.

Literature Review

Lee D. et al. [1] the purpose of this paper is to study was on the creep behavior of 7075 Al alloys. The stress exponent value in static creep was 8.9 and in cyclic creep were 8.7. They decreased with increasing temperature. It was found from the SEM results that the fracture mode in 7075 Al alloys was trans granular. The Cr-dispersions ($Al_{18}Cr_2Mg_3$) distributed extend extensively across all the grains were responsible for a rapid increase in void formation, resulting in ductile failure. The rupture time is strongly dependent on the dispersions size.

Zhang K. et al. [2] this paper studies that the presence of SiC particles may restrict crystal growth of primary phase during laser rapid solidification of an aluminum 7075 alloy. Under the condition of higher volume fraction of larger particles, non-epitaxial grain development is favored in laser resolidified zone.

Chang S. et al. [3] there were two ways employed to experimentally determine the tube spin ability of the full-annealed and solution-treated Al 2024 and 7075 aluminum alloys. Tube spin ability was defined as the maximum thickness reduction before either fracture or buckling under the given roller geometry, feed rate, and the speed of the mandrel during the tube spinning of a metal. One was to reduce the thickness stepwise to the final thickness without failure the tube. The other was the one-path spinning with continuous reduction in wall thickness of perform from initial to the final thickness without buckling to determine the achieved maximum reduction.

Panigrahi S. et al. [4] the purpose of this paper is to the effect of annealing on microstructural stability, precipitate evolution, and mechanical properties of cry rolled (CR) Al 7075 alloy was investigated in the present work employing hardness measurements, tensile test, X-ray diffraction (XRD), differential scanning calorimetry (DSC), electron backscattered diffraction (EBSD), and transmission electron microscopy (TEM). The solution-treated bulk Al 7075 alloy was subjected to cry rolling to produce fine grain structures and, subsequently, annealing treatment to investigate its thermal stability. The recrystallization of CR Al 7075 alloys started at an annealing temperature of 423 K (150 ^{0}C) and completed at an annealing temperature of 523 K (250 ^{0}C). The CR Al 7075 alloys with ultrafine-grained microstructure are thermally stable up to 623 K (350^{0}C). Within the range of523 K to 623 K (250 C to 350 ^{0}C), the size of small g phase particles and AlZr3 dispersoids lies within 300 nm. These small precipitate particles pin the grain boundaries due to the Zener pinning effect, which suppresses grain growth. The hardness and tensile strength of the CR Al 7075 alloys was reduced during the annealing treatment from 423 K to 523 K (150 ^{0}C to 250 ^{0}C) and subsequently it remains constant.

Amoush A. et al. [5] the purpose of this paper is to the corrosion behavior of high strength aluminium alloy type 7075-T6 precharged with hydrogen for various charging times was investigated using electrochemical polarization and free corrosion potentials measurement techniques. The results showed that the precharged 7075-T6 aluminium alloy with hydrogen exhibited lower open-circuit (OCP) and breakdown potentials in deserted 0.5M NaCl than those for the no hydrogenated material. Moreover, the OCP and breakdown potentials decreased with increasing the precharging time. Microscopic observations of the exposed surfaces revealed that intergranular attack was formed in non-hydrogenated specimens whereas mixed mode of attack (i.e. intergranular and transgranular) were formed in the precharged ones during potentiostatic polarization.

Lung B. et al. [6] the purpose of this paper is to the effect of homogenization and aging treatments on the strength and the stress-corrosion cracking (SCC) resistance of the 7050 aluminum alloy has been investigated and compared with those of the same-series 7075 alloy. The recrystallized structure and the quench sensitivity are found to be significantly affected by the dispersoids distribution, depending on the homogenization conditions. The finest and densest dispersoids distribution, generated by the step homogenization (Step-H) treatment, can effectively inhibit recrystallization to obtain the smallest fraction of recrystallized structure.

Nishida Y. et al. [7] the purpose of this paper is to found a new-scheme ECAP process using a rotary die was applied to a SiC whisker-reinforced aluminum alloy-matrix composite. A squeeze cast 20 vol% SiC whisker/7075 alloy composite has been successfully processed by RD-ECAP. An essentially uniform distribution of SiC whiskers was achieved after 10 ECAP passes. After 10 ECAP passes at 573 K, the matrix grain size was about 1.5–2 μm. 10 ECAP passes at 573 K were sufficient to convert the low-ductility, as squeeze cast composite, into a superplastic composite. Elongation values up to about 175% were achieved together with the strain rate sensitivity coefficient of about 0.67.

Dai W. et al. [8] high-intensity ultrasonic wave was conducted into aluminum alloy 7075-T6 to observe the effect of emission waves on the weld ability during inert gas tungsten arc (GTA) welding. Through the heat-affected zone (HAZ) and the weld, the ultrasonic-wave emissions with different paths are examined and directly correlated to the heating time, dwell time, cooling rate, as well as peak temperature of the thermal cycle, and to the grain growth, weld penetration, and hardness. In addition, a methodology based on the characteristic curves of the relative amplitude ratios of the reflected longitudinal wave and vertical shear wave for improving the weld ability of aluminum alloy 7075-T6 is presented.

Hidalgo P. et al. [9] the 7075 alloy is an Al-Zn-Mg-Cu wrought age-harden able aluminum alloy widely used in the aeronautical industry. The alloy was accumulative roll bonded at 300 ^{0}C (573 K), 350 ^{0}C (623 K), and 400 ^{0}C (673 K), and the microstructure, texture, and hardness were investigated. Cell/(sub)grain size in the nanostructured range, typical b-fiber rolling texture, and homogeneous hardness through thickness were determined in all cases. Misorientation was different at each processing temperature. At 400 ^{0}C, the presence of elements in solid solution and the partial dissolution of the hardening precipitate lead to a poorly misoriented microstructure with a high dislocation density and a homogeneous b-fiber texture of low intensity, typical of intermediate degrees of rolling. At 350^0 C and 300 ^{0}C, highly misoriented microstructures with smaller dislocation density and intense heterogeneous b-fiber rolling texture are observed, especially at 350^0 C.

Horita Z. et.al. [10] The study use equal-channel angular (ECA) pressing at room temperature, the grain sizes of six different commercial aluminum-based alloys (1100, 2024, 3004, 5083, 6061, and 7075) were reduced to within the sub micrometer range. These grains were reasonably stable up to annealing temperatures of ,2008C and the sub micrometer grains were retained in the 2024 and 7075 alloys to annealing temperatures of 300 8C. Tensile testing after ECA pressing through a single pass, equivalent to the introduction of a strain of,1, showed there is a significant increase in the values of the 0.2 pct proof stress and the ultimate tensile stress (UTS) for each alloy with a corresponding reduction in the elongations to failure.

Neag A. et al. [11] the purpose of this paper is to study the microstructure and flow behavior during thixo backward extrusion of 7075 aluminium alloy were investigated. Reheating the steel die and the aluminium billet placed into the die at the same time using an induction furnace provides rapidly a very homogeneous microstructure suitable for thixoforming. During

Thixoextrusion, despite the high solid fraction, the solid globules are weakly connected and slide over each other without any plastic deformation. The flow remains quasi homogeneous resulting in homogeneous induced microstructure of the component.

Ortiz D. et al. [12] the purpose of this paper is to study Aluminum alloys 6061, 2024, and 7075 were heat treated to various tempers and then subjected to a range of plastic strain (stretching) in order to determine their strain limits. Tensile properties, conductivity, hardness, and grain size measurements were evaluated. The effects of the plastic strain on these properties are discussed and strain limits are suggested.

Pataric A. et al. [13] the purpose of this paper is to obtain the better quality of an aluminium super-high strength alloy by application of electromagnetic field during the casting process. The conventional continuous casting process of aluminum alloys causes many defects, such as surface imperfections, grain boundary segregation, non-uniform grain size, and porosity. The better ingot surface along with the homogeneous fine-grained microstructure, and hence the better mechanical properties of the ingot, can be achieved by applying the electromagnetic casting process. The microstructure characterization, accompanied by quantitative metallographic assessment, reveals that it is possible to avoid or decrease many defects of as cast ingots during electromagnetic casting process

Materials Used

6063 Aluminum Alloy: 6063 is an aluminum alloy, with magnesium and silicon as the alloying elements. 6063 is mostly used in extruded shapes for architecture, particularly window frames, door frames, roofs, and sign frames. It is typically produced with very smooth surfaces fit for anodizing.

Table 1 Chemical composition of 7075 Aluminium alloy (mole %)

Si	1.031
Fe	0.432
Cu	0.055
Mn	0.5
Mg	0.76
Cr	0.012
Ni	0.009
Zn	0.038
Ti	0.058
Pb	0.01
Al	97.1

Methodology and Procedure

1. Melting the raw material in melting furnace.
2. Cast the billet into hot top billet casting.
3. For RAP process billets must be heated to approximately700 ºC.
4. Metal is transferred (via belt or walking beams systems) from the run-out table to the cooling table.
5. After the aluminium has cooled and moved along the cooling table, it is then moved to the stretcher. Stretching straightens the extrusions and performs 'work hardening' (molecular realignment which gives aluminium increased hardness and improved strength).
6. The next step is sawing. After extrusions have been stretched they are transferred to a saw table and cut to specific lengths. The cutting tolerance on saws is 1/8 inch or greater, depending on saw length.
7. After the parts have been cut, they are loaded on a transportation device and moved into age ovens for aging process. Heat-treating or artificial aging hardened the metal by speeding the aging process in a controlled temperature environment for a set amount of time.
8. After the aging operation the next important thing is studies its different mechanical properties which includes strength , hardness etc. of material
9. **Output Parameters:** The output parameters are Brinell & Rockwell hardness.

Result and Analysis of Hardness

Brinell Hardness Result and Analysis of Al-6063

S.No.	Alloy	Temperature	Brinell Hardness (HBW)	
			Trail 1	Trail 2
1	6063	545°C	83.9	83.9
12	6063	545°C	93	90.7
3	6063	560°C	84.9	76.3
4	6063	560°C	79.7	82

Rockwell Hardness Result and Analysis of Al-6063

S.No.	Alloy	Temperature	Rockwell Hardness (HRC)	
			Trail 1	Trail 2
1	6063	545°C	9	9.5
2	6063	545°C	10	9.5
3	6063	560°C	8.5	7.5
4	6063	560°C	9	8

Conclusions

Following conclusions has been generated in the present study:

The mean value of Rockwell hardness of Al- 6063 alloy at 545°C was found 9 HRC and at 560°C was 8 HRC.

The mean value of Brinell hardness of Al- 6063 alloy at 545°C was found 88 HBW and at 560°C was 82 HBW.

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