A REVIEW ON INFLUENCE OF MULTI AXIAL FORGING OF AZ 31 MAGNESIUM ALLOY ON FORMABILITY

Orugonda Ravali[1], Anoop kumar[2]
[1,2]Department of Mechanical Engineering
St. Martin's Engineering College Dhullapally, Hyderabad, T.S.

Abstract
The Magnesium alloy is a light weight material and preferably used for aeronautical application. Due to its hexagonal close packed structure the alloy is having less formability and workability. In this review study the processing of the material is highlighted and accordingly the microstructure of the material got transformed from micron to submicron level and the mechanical properties improved.

Keywords: Formability; Multiaxial Forging; microstructure.

INTRODUCTION

Formability is the ability of the material to be formed into a desired shape. Metal forming had been practiced by blacksmith from ages. From those ages there is an increase in the automotive industy demand, understanding the formability has accelerated [1]. A Material to be used in industries should achieve a definite shape, it should undergo plastic deformation, however every material has some capacity to withstand against failures like tearing, fracture [2]. It is recognized that from decades many authors struggling to improve the material mechanical properties like ductility, drawability etc. suitable for forming a material. The material is formed with or without heating then after forced it under vaccum or air pressure into a mold. The forces applied in the formability are primarily compressive or tensile [3]. Glenn S et al. described the factors effecting formability are high velocity , pressure, sample size and die impact. At a particular high velocity sample can inhibit neck growth, ductility of the sample depends on its size and boundary conditions imposed by die impact [4]. S. Bruschi et al. described necessary considerations to estimate the mechanical behavior of the material are (a) processing of a material that changes its microstructure, hence the desired properties can be obtained (b) final product performance is based on both the properties of the synthesized material (c) therefore materials should contain feasible mechanical properties and can be improved by a particular process[5]. Thus it is derived that properties of the material depends on microstructure of that material. Several studies of microstructure evaluation and grain refinement during different processes have been carried out with a view on re- crystallization. The re crystallization can achieve uniform development of finer grains which improves formability, workability and mechanical properties. This review paper gives a brief understanding how mechanical properties improved for a better formability with grain refinement of AZ31 Mg alloy using multi axial forging(MAF).

AZ31 Magnesium alloy

Magnesium alloys have gained an attention of many researchers for its use in automobile, aerospace and biomedical applications. Mg alloys are light weight materials with density ranges from 1.7 to 2.0 g/cm^3 which is less than titanium and stainless steel. One of the magnesium alloys AZ31, is a wrought magnesium alloy used in automotive and aerospace industry due to its good mechanical properties.Pure magnesium alloys has low mechanical strength so it should be alloyed with some other substances which enhace strength, heat resistance, workability, corrosion resistance and weldability. The composition of AZ31 Mg alloy is given in Table 1.

Table 1.composition of AZ31 Mg alloy

AZ31 alloy	Al	Zn	Mn	Cu	Mg
%weight	2.83	0.80	0.37	0.002	balance

Applications of AZ31 are air craft brakets, air craft fuselages,cell phones, laptop cases and concrete tools [6]. AZ31 is a good extrusion alloy with a hexagonal closed packed structure [7]. AZ31 alloy has high tensile proof strength due to stringy texture in a deformed direction and low compressive strength due to twinning , happens easily with hexagonal structure [8]. The mechanical properties of AZ31 mg alloy as shown in the table 2.

Table 2 : The mechanical properties of AZ31 mg alloy:

Tensile strength	Melting point	Recrystallization temperature
290 Mpa	630^{o}c	300^{o}c

Due to its moderate ductility and strong anisotropic character AZ31 alloy is not used widely. According to Somjeet Biswas and Satyam Suwas, when magnesium alloys processed under high temperature, leads to dynamic recrystallization which diminish mechanical properties [9]. To obtain better formability a uniform fine grain microstructure is required .

Grain refinement of AZ31

The micro structure of a material is the mainly responsible for the properties of that material. Thus with the grain refinement of material one can achieve better properties. Many authors observed the grain refinement of AZ31 mg alloy processed under various methods and gave appropriate properties developed as processing conditions. Commercially rolled AZ31 sheet of 0.8mm thickness was taken and annealed at 673 K [10].The sheet was deep drawn with a small punch radius of 1.0mm. By heating the specimen from 373 to 473K, there is a remarkable increase in ductility. An investigation on fracture mechanics and forming limit was done under low temperature near to room temperature. The fracture in the deep drawing caused by bending under tensile stress.Thus at higher temperature material reaches near to recrystrallisation point thus changes in the mechanical properties [10]. Rolled AZ31 Mg alloy was analyzed to improve press formability by single roller drive rolling[11]. Thus an attempt was made to attain both grain refinement and control of texture. The results obtained are compared with normal rolling of the same material. After the processing it is identified that grain size was obtained as same as normal rolled specimens.The press formabiity of single roller drive rolling is better than the normal rolling. Due to the weaker intensity of texture leads to twinning, resulting low planar anisotropy. Thus grain refinement of a material can improve formability [11]. The hot rolled AZ31 alloy was warm deformed under a temperature range of 50-200^{o}C.The study was carried out on dynamic recrystrallisation and twinning. It was found that the accumulation of distorsion energy due to twinning which give rise to dynamic recrystralisation and when the differently oriented twins intersecting each other is the deformation mechanism at low temperatures [12].Yasumasa Chino et.al.experimented on AZ31 Mg alloy under rolling operation. The operation was performed in two ways i) rolling `again by changinging rolling direction of 90^o ii) rolling again in the same direction.Thus improved formability in rolled mg alloy sheets were observed with controlled texture. The controlled texture was achieved by changing the direction of rolling. Therefore, it is observed that texture control can lead to better formability at lower temperatures[13]. The importance of processing methods, deformation behavior, texture and microstructure evolution was explained by T. Al Samman et. al. Under the same conditions of temperature and strain rate, six samples which are differently processed are investigated. They concluded as maximum ductility obtained for the hot rolled sample ,also in some specimens tensile twinning, compression twinning and double twinning were observed and correlated to micro crack formation[14]. Anna dziubinska et. al. explained AZ31 alloy is one of the most popular magnesium alloys, this alloy is used in the air craft industry to produce flat partswith ribs, such as brakets. They employed a new technology of semi-open die forging to a specimen with a dimensions of 74×50×9.5 mm cut from a plate of AZ31 mg alloy. The initial plate was heated to a temperature of 410^{o}C, and placing the plate in between two tools which are heated to 200^{o}c. These tools were moved horizontally under the action of upper punch with the velocity of 6m/s.

They concluded that the forged plate had large heteroginity of structure and also observed largest fragmentations of structure took place in some areas due to larger strains. In order to attain homogeneous structure, more heat treatment processes were advised[6].Jie Xing employed a new methodology to optimize the grain structure and to improve mechanical properties. They experimented with AZ31 Mg alloy under multi-directional forging with decreasing temperatures from 623 to 423 K. With repeated multi-directional forging under decreasing temperatures average grain size 0.36µm was obtained. The study on dynamic grain size was carried out using Hall-Petch relation [7].

Multi-Axial Forging

In subsequent years, with advancement of technology to develop ultra-fine grained materials, severe plastic deformation became an essential methodology. Hence the processed materials achieve better ductility strength, ductility fracture resistance , fatigue and toughness than bulk materials [15, 16].Some of the methods of severe plastic deformation are Equal channel angular extrusion, High pressure torsion, Accumulative roll bonding, Repetitive corrugation and straightening and Asymmetric rolling. These process are used to obtain Ultra-fine grained materials [17,18]. Every process had their own limitations which has a limited use in industries. These processing techniques require expensive dies and can achieve only low productivity. One of the most promising method of severe plastic deformation is Multi Axial Forging (MAF),which is a simple method to achieve ultra-fine grained materials. MAF involves repeated compression on the sample ,changes the axis to 90^o in every pass. Many magnesium alloys were processed under multi axial forging and observed better results in the form of grain size and properties [19]. Somjeet biswas et. al. experimented on magnesium alloy Mg-3Al-0.4 Mn and obtained a sub micron size, weak texture when processed under modified multi axial forging. They made an attempt to develop the process between the existing MAF process and channel die compression. After two cycles of operation found that strength and ductility are influenced by both fine grain size and weak texture when processed under MAF [9]. P.Trivedi et al studied the grain refinement to submicron of Mg-2Zn-2Gd alloy when processed under MAF, the observations made after the completion of process were as (i) achieved UFG to submicron grain size (ii)Tensile strength of 272 MPa was obtained and suggested improved mechanical properties which were suitable for automotive applications [20]. Xu-yue Yang et al studied grain size and texture modifications of AZ31 Mg alloy during MAF. Multi directional forging under decreased temperature condition can accelerate development of grain size and increases the workability at low temperature . They reported that multi directional forged alloy showed good strength but modulate ductility at room temperature, and at 423K the super plastic flow was observed [21]. Thus MAF is one of the promising method to obtain a uniform texture and can obtain better mechanical properties for a better formability.

Conclusion

Multiaxial forging was proved as an promising grain refinement process and it improved mechanical properties. it enhanceed ductile behaviour of material and influenced the workability and formability of material. The press formabiity of single roller drive rolling was found better than the normal rolling.

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