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Optimization of Hot Extrusion Process Parameters Using Taguchi Based Grey Relation Analysis:
An Experimental Approach

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ABSTRACT

Enormous applications of aluminium alloys in various key industries necessitated the development and improvement of material processing techniques. Due to simplicity in making complex shapes and low cost of production, the extrusion process for aluminium has gained great popularity in recent years. As the processing variables/parameters during any manufacturing process significantly effects the yield and mechanical properties of extruded products, the development of optimal process parameters combination is found to be vital for the modern manufacturing industries. Hence, the present article addresses the conducting of hot extrusion experiments with AA6061 and evaluation of optimal process parameters using a Taguchi-based GRA. To check the significance of the processing variables on the output quality and quantity, ANOVA is used. A confirmation test was done at the selected optimal processing parameters combination to validate the experimental results.

KEYWORDS

ANOVA, GRA, Hot Extrusion, Optimum Process Parameters, Taguchi Method

1. INTRODUCTION

Development of an advanced material in the field of engineering application due to its excellent mechanical properties has brought a wider attention of global research. Because of their high strength-to-density ratio, Aluminium alloys are the most desirable materials for structural applications. They can also be easily machined and extruded, have good corrosion resistance, good electrical and thermal conductivity, and are heavily recycled. AA6061 is one of the most commonly used aluminium alloy used in components of transportation and machinery equipment due to its excellent corrosion resistance to both atmosphere and sea water. In addition, it is the most commonly used material for extrusion process due its good formability and considerable strength. There are various processing techniques to suit this type of advanced material.

Extrusion is the secondary metal forming process for transforming the cast structure of an ingot in to a useful end product with enhanced properties by altering the material shape and size from. By simply altering the die and the associated tooling, various profiles can be obtained. And moreover, extrusion in hot working conditions is abundantly used for the direct recycling of aluminium machining chips. In recent years, extrusion process finds its application in manufacturing different varieties of profiles in both solid and hollow form. The amount of force required to extrude the material known as Extrusion

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load is the main objective in this manufacturing process. The forming variables which directly affect the extrusion force are ram speed, extrusion ratio, cone angle, lubrication and property of the material to be extruded. These processing parameters will greatly influence the mechanical properties and surface structure of the product being extruded. The main objective of any manufacturing process is to produce good quality product with minimum cost is by lead time reduction in design cycle, tooling cost, machine downtime. Generally, die design will be based on the trial and error and also based on the experience. Since the process parameters greatly influence product quality and yield, they have to be selected properly. Hence most of the present manufacturing research inclined towards the evaluation of optimal process parameters for the best quality of the product.

Venkatesh and Venkatesan (2015) have conducted hot extrusion experiments with SiC/AA6061 for the parameters optimization . The influence of the process parameters namely, initial billet temperature ram speed, and friction were studied using L9 OA of Taguchi method. Experimental responses were analyzed with average response method. Results showed the optimum process parameters as 3mm/min ram speed, 450°C initial billet temperatures and 0.1 friction factor for minimum extrusion load. Chaudhari et al. (2012) carried Experimental evaluation to study the influence of cone angle of die on surface finish and hardness of cold forward extrusion of AA1100 with different lubricants. The optimum extrusion load was found below 45° cone half angles of die and there were not many variations found in surface finish with respect to the die angle. At 30° and 60° die angles and with the lubricant petroleum jelly, hardness was found higher. Chahare and Inamdar (2017) obtained the optimal processing parameters for feature angularity by considering the factors, container temperature, ram speed and billet pre-heating temperature. The results showed that 500°C billet temperature, 400°C container temperature and 6mm/s ram speed gave best results. Sirsgi et al. (2015) performed Taguchi based Numerical Analysis to optimize die angle for minimum load and maximum tensile strength of extruded tubes in hot working using AA6061, AA6063 & AA7075. Adeosun et al. (2013) studied the influences of parameters like die angle, die material and initial temperature on aluminium alloy characteristics like extrusion load, strain and surface hardness of the extrudes. Hsiang and Lin (2007) investigated the influence of parameters in hot extrusion on magnesium alloy AZ31 and AZ61tubes. Mechanical properties were evaluated by varying the processing parameters and the results were analysed with Taguchi method. Gattmah et al. (2017) studied the influence of friction coefficient, reduction ration and ram speed on surface temperature of AISI316L hollow tube in hot extrusion. Results proved that rise in ram speed, friction coefficient and the reduction ratio increases the surface temperature of the extruded tube. Lu et al. (2015) performed investigation to study the influence of processing parameters, deformation temperatures and reduction ratios on mechanical properties and microstructure during hot extrusion of AZ61 alloy. Grain size was greatly refined with the rise in deformation temperature and mechanical properties got improved with the rise in reduction ratio.

Jajimoggala (2018) simulated hot extrusion process ofAA6061-fly ash composites in D-form 3D and evaluated optimal process parameters for minimum extrusion load and maximum yield. Zhang et al. (2012) simulated extrusion process in HyperXtrude on aluminum profile and the influence of processing variables on the extrusion load and metal flow uniformity were studied using Taguchi's method with S/N analysis. Sharififar and Akbari Mousavi (2015) carried investigations on numerical simulations and optimization of hot extrusion processing parameters while manufacturing rectangular waveguides. Taguchi method, artificial neural networks and genetic algorithms were used to study the relationship among influential parameters and to optimize the extrusion load. V Kumar et al. (2013) investigated the influence of die angle on the extruded product mechanical properties, like hardness and surface finish by conducting the experiments on a nano SiC composite in both hot and cold extrusion and the results were compared. Kumar and Vijay (2007) have designed, fabricated and carried out experiments on H, T, L, elliptical shaped extrusions of AA2024 and 70Pb30Sn in hot and cold working conditions using two types of dies i.e., flat and conical. Zhao et al. (2013) applied Taguchi's design of experiments followed by numerical simulations in hyperxtrude to analyze the extrusion of AA6063 and for uniform flow velocity distribution, the optimum process parameters combination was obtained. Rhee et al. (2004)

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