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Original Research Article

PARAMETERS OPTIMIZATION OF THE MECHANICAL PROPERTIES FOR ANNEALED ALUMINIUM ALLOY

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ABSTRACT

Optimal selection of process parameters is very much essential as this is a costly process to increase production rate considerably by reducing the machining time. With the advent of newer technologies, search for new materials were started with the aim to fulfill various requirements needed in future and also search was aimed to improve material to suit the present requirements. In view for the improvement of properties of various metals and alloys (ferrous and non-ferrous), it has been seen that heat treatment is the most effective way. In this investigation studied on the mechanical properties of Aluminum alloy Al 5052 at different annealing temperature, holding time and cooling process which saw how it affects different mechanical properties such as toughness of Aluminum alloy Al 5052. An experimental investigation was carried out based on Taguchi L9 orthogonal array to analyse the sensitivity of mechanical properties attributes to the variations in process parameters such as different annealing temperature different types of cooling, with variation of holding time. Weighing factors for the output responses were determined using triangular fuzzy numbers and the most desirable factor level combinations were selected based on Grey Relation method technique.

1. INTRODUCTION

Materials possessing not only enhanced properties but also high performance capabilities with high strength, high hardness, temperature resistance, corrosion resistance to weight ratio for modern advanced industries like manufacturing, automotive, nuclear, aeronautics and die making industries. In accordance to this there is a huge demand for advanced technologies to face the challenges posed while manufacturing components with such materials. To cope up with this difficult to machine materials problem, traditional manufacturing processes are being replaced by more advanced techniques, which use different form of energy to remove material. In general heat treatment basically modifies microstructures and thereby produces a variety of mechanical properties that are important in manufacturing, such as improved formability and machinability. Annealing is considered the most important heat treatment process as it helps to stabilize the microstructure.[1] The metals which do not have iron in their composition are known to be Non-ferrous metals. Also there melting points are relatively lower than those of ferrous ones. Alloys of these non ferrous metals are now-a-days finding their use more as compared to their ferrous counterparts. This increase in demand for these alloys is because of their unique characteristics like corrosion resistance, light weight, non magnetic and good conductor of heat and energy. Naturally aluminum finds its application in very few areas. This is because it is soft and fragile when it is pure. But its applicability is increased by alloying. When aluminum is alloyed with other metals it increases its hardness and acquires adequate strength but it maintains its light weight. The designation to this type of alloy is comprised in the following manner, the first digit indicates the major alloying element which is magnesium here, and next digit describes the type of modification and the third and fourth place for other alloying elements. This alloy is basically popular due it properties like good workability, good mechanical strength and very good corrosion resistance, especially in marine conditions.

2. MECHANICAL PROPERTIES OF MATERIAL

Characteristics of any material which describes the materials behavior under external loads are commonly referred as mechanical properties. As we know that all engineering components are likely to subject to external loads directly or indirectly, it is therefore, necessary to have knowledge of the mechanical properties so as to avoid the chances of failures. These characteristics which are known as mechanical properties greatly rely on the structure of the material especially about the microstructure arrangement. Commonly known mechanical properties are Strength, Hardness, Toughness, Resilience, Stiffness, Elasticity, Plasticity, Ductility, Malleability, etc.

3. OBJECTIVE OF WORK

Also in recent past Aluminum alloy Al 5052 showed its presence more rapidly and there's an urgent need for enhancement and investigation of its mechanical properties. Attempts have been made by various scholars in this area. The present study is focused on how the mechanical properties such as strength, ductility, toughness and hardness behave or change when Aluminum alloy Al 5052 is annealed to different temperatures. This not only helps to study the behavior of the material but also makes it more effective in utilization in various sectors. Development of industrial growth and globalization more and more advancements have been witnessed in the scientific area especially into R & D for providing new technology and materials so as to make improvements in the existing technology and things [24]. The objective of this investigation is to study the behavior of mechanical properties due to change in the annealing temperature of Aluminum alloy Al 5052. In this context the following activities are aimed to carry out.

1. Preparation of samples for respective test according to ASTM Standards.
2. Design the experiment by L9 OA method under the controlled parameter then perform Annealing of samples of Aluminum alloy Al 5052 under controlled conditions as per DOE.
3. Determination of Mechanical properties viz. strength, ductility, toughness and hardness of these samples.
4. Optimize the parameter to select the best option which increase the performance of aluminum alloy.

4. DESIGN OF EXPERIMENT

The DOE technique and the number of levels are to be selected according to the number of experiments which can be afforded. By the term levels we mean the number of different values a variable can assume according to its discretization. The number of levels for all variables are compatible as per their requirement i;e DOE techniques uses the differentiation of the number of levels for each variable as shown in table 1

Table 1 Factor and level

Annealing temperature in ^{o}C	Holding timein minutes	Type of cooling
300	20	Room temperature
325	25	Sand cool
350	30	Oil cool

Orthogonal arrays are special standard experimental design that requires only a small number of experimental trials to find the main factors effects on output. On the basis of factors and their level L9 orthogonal array has to be design in Minitab software.

5. GREY RELATION ANALYSIS

The grey means the primitive data with poor, incomplete, and uncertain information in the grey systematic theory; the incomplete relation of information among these data is called the grey relation. First, the grey relation analysis was carried out to normalize the responses; surface roughness and chemical wear was normalized by given equation (1).

For lower-the-better criterion, the normalized data can be expressed as

$$X_i = \frac{max(y)_i - (y)_i}{\max(y)_i - \min(y)_i} \qquad \ldots..(1)$$

$$where\ i = 1,2 \ldots..n$$

The calculation of the grey relational coefficient and the weight of each quality characteristic is determined by equation (2):

$$G_i = \frac{L_{min} + \varepsilon L_{max}}{L_i(k) + \varepsilon L_{max}} \qquad \ldots\ldots(2)$$

Where, Lminis the global minimum, Lmax is the global maximum and ε is distinguish coefficient which is taken in between 0 to 1 in this case 0.5 weight is taken.

Grey relation grade can be calculated by equation (3)

$$Grg_i = \frac{1}{n}\sum_{j=1}^{n} G_i(j) \qquad \ldots\ldots\ldots\ldots(3)$$

Where n is the number of process responses. The lower value of the grey relational grade represents the reference sequence Grgi. As mentioned before, the reference sequence Grgi is the best process response in the experimental layout. The lower value of the grey relational grade means that the corresponding cutting parameter is closer to optimal.

6. RESULT

The results of different mechanical properties toughness under DOE were observed and recorded in Table 2. Following points can be asserted from the results received. The optimization of toughness test in terms of charpy and izod test can be made combine to make it multi-objective problem both optimization has been done by grey relation method as shown in table 3 respectively.

Table 2 Toughness result of aluminium alloy Al 5052

Annealing temperature in oC	**Holding time in minutes**	**Type of cooling**	**Toughness**	
			Charpy test (Nm)	**Izod (Nm)**
300	20	Room Temp.	248	114
300	25	Sand Cool	253	111
300	30	Oil Cool	250	107
325	20	Sand Cool	271	103
325	25	Oil Cool	268	98
325	30	Room Temp.	265	96
350	20	Oil Cool	264	97
350	25	Room Temp.	261	95
350	30	Sand Cool	258	93
Normal Alloy			271	123

Table 3 Optimization of toughness test

S. No.	**Charpy**	**Izod**	**N_{ij}Ch**	**N_{ij} I**	**G_iCh**	**G_i I**	**GRG**
1	248	114	0	1	0.333333	1	0.666667
2	253	111	0.217391	0.857143	0.389831	0.777778	0.583804
3	250	107	0.086957	0.666667	0.353846	0.6	0.476923
4	**271**	**103**	**1**	**0.47619**	**1**	**0.488372**	**0.744186**
5	268	98	0.869565	0.238095	0.793103	0.396226	0.594665
6	265	96	0.73913	0.142857	0.657143	0.368421	0.512782
7	264	97	0.695652	0.190476	0.621622	0.381818	0.50172
8	62.74	328.46	0.765909	0.067078	0.681115	0.348937	0.515026
9	63.54	324.22	0.826515	0	0.742407	0.333333	0.53787

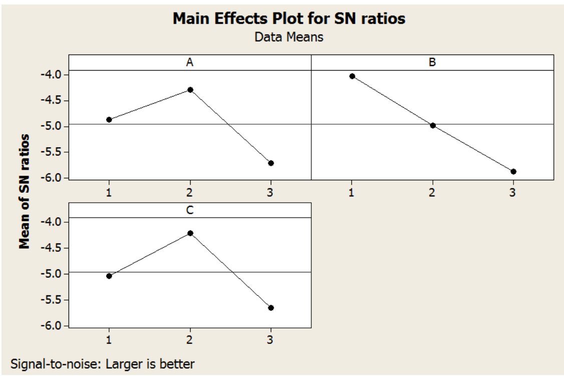

Fig. 1 SN ratio graph of toughness

7. CONCLUSIONS

The following conclusion can be drawn from the present investigation on mechanical properties of aluminum alloy Al 5052.

i. There is strong influence of annealing on the mechanical properties of aluminum alloy Al 5052. The annealing process decreases the tensile strength, hardness and toughness of the material while increasing the ductility as per the parameter design by DOE which is observed to compare original properties value to their experimented properties value.
ii. The optimization process shows that both have result gives in same parameter that is 325^{o}C temperature with 20 min holding time and sand cooling is apply.
iii. As per the both category optimization shows that optimum parameter gives best responses on mechanical properties for increasing ductility of material with other properties might have good result.

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