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Optimization of Process Parameters of Friction Stir Welded Mg alloys for Maximizing Mechanical Properties

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Abstract: ***Mechanical properties of alloy such as UTs, surface hardness etc. of friction stir welding (FSW) jones were largely depend on the parameters of welding, such as speed of rotating tool, feed rate and axial thrust etc. by optimizing these parameters will results in better design of the weldments. To attain desired mechanical properties various optimizing techniques are available. In this paper an experiment is conducted on by varying process parameters and evaluating the mechanical properties (UTs) of the friction stir weldments. From the collected information data is created and used to create a mathematical model for optimization of the process parameters.***
Keywords: Mechanical Properties, Sound design, Weldments, Optimization, Friction

I. INTRODUCTION

The application of Mg and its alloys in Bio medical field and structural application is rapidly increasing because of some user friendly properties of Mg as inplants in ortho-paedic applications and structural applications. The mechanical properties of Mg and other elements alloys including tensile yield strength respectively are gathered as extensive data and published in literature. In addition the varying process parameters on mechanical characteristics are also gathered and reported. The demand for high strength Equipments in structural applications is ever increasing. Any attempt made to address above issues will help in realizing excellent results. However to fix the methodology of manufacturing such high strength alloys, we primary need an extensive survey of the work till date carried out in above area. Hence a sincere attempt is made in this paper to review and understand the research work carried out till date, on the strength properties of friction stir weldments with variation of process parameters to identity the associated issues and challenges and to identity the thrust areas of research to address above issues.

A. Theory of Optimization

The optimization problem proposed in this work consists of finding X (an n-dimensional vector called design vector) which minimizes f(x). or mathematically it can be stated as

Find x = (x1, x2,….xn), which

Minimizes / Maximizes f (x)

Subject to the constraints.

gm(x)=0, j=1,2,……m

lj(x)=0, j=1,2,……p

where f(x) is called as objective function.

g(i) and lj(x) are known as inequality and equality constraints. It the problem does not involve any such constraints then the mathematical model takes the form.

Find(x) =(x1,x2……xn) which minimizes / Maximizes f (x).

Some of the parameters of design vector x (namely x1,x2,…xn) are considered as variables. In general certain variables are fixed and are called as preassigned parameters. All other quantities are treated as variables and are called design or decision variables. The design variables are collectively represented as a design vector.

X = x1,x2….xn.

In the present work, let the parameters speed of the rotating tool in rpm, feet of the tool in mm/sec and axial force in kN, be the design or decision variables.

X= (x1,x2,x3) = (N, f, F)

A design space can be formulation by fixing 2 dimensional Cartesian space. Each point in the space is called a design point, and represents either a possible or impossible solution. A negative value for X1 or x2 or x3 offers an impossible solution.

Further the design variables N, f and F cannot be chosen arbitrarily. They have to satisfy certain requirements of design constraints. These constraints can be either behavior constraints or side constraints. In general more than one acceptable solution exists for such above problems. The purpose of proposed optimization is to choose the best one of the many acceptable design variables. Thus a criteria has to be chosen for comparing different acceptable designs. The criteria with respect to which the design is optimized, when expressed as a function of the design variables is known as objective function.

In a multiobjective programming problems, there can be more than one criterion to be satisfied simultaneously. Further the objectives may conflict each other. In such cases an overall objective function in the form.

$f'(x) = \alpha 1\ f1(x) + \alpha 2\ f2(x)$

Can (where α1 and α2 are constants indicating the relative importance of one objective function over the other) can be written and optimized.

II. LITERATURE REVIEW

A K Lakshminarayanan etal [1], made broad work on "Microstructure Tensile and Impact Toughness Properties of Friction Stir Welded Mild Steel", and their outcomes are as demonstrated underneath. Microstructure, ductile and sway sturdiness properties and break area of grinding mix welded AISI 1018 gentle steel were uncovered. The AISI 1018 gentle steel plates with thickness of 5 mm were grating mix welded by tungsten based composite apparatus with instrument rotational speed of 1000 r/min and welding velocity of 50 mm/min. The flexibility and effect durability of the joints are diminished contrasted with those of the base metal attributable to the consideration of tungsten particles in the weld locale.

S. Malarvizhi etal [2], accomplished broad exploration work on "Impact of welding measures on AA2219 aluminum combination joint properties", and have comeout with the accompanying outcomes. AA2219 aluminum compound square butt joints without filler metal expansion were created utilizing gas tungsten bend welding (GTAW), electron shaft welding (EBW) and contact mix welding (FSW) measures. The impacts of three welding measures on the tractable, exhaustion and erosion conduct were contemplated. The outcomes show that the FSW joints display better malleable and erosion properties analyzed than EBW and GTAW joints. It is additionally tracked down that the grating mix welds show lower erosion opposition than EB and GTA welds. This is principally because of the presence of better grains and uniform dissemination of reinforcing encourages in the weld metal of FSW joints.

S. Babu etal [3], dealt with "Improving the ballistic resistance of covering steel weldments by plasma moved circular segment (PTA) hardfacing" and distributed the accompanying outcomes. From the outcomes, the welds with sandwiched interlayer halted every one of the shots effectively, regardless of cycles utilized, while welds without sandwiched interlayer were fizzled. The variety in microstructure and hardness at different zones of the weld are examined.

G. Padmanaban etal [4], accomplished broad test work on "Exhaustion execution of beat current gas tungsten curve, rubbing mix and laser shaft welded AZ31B magnesium combination joints", to distribute the accompanying. This paper reports the impact of welding cycles, for example, rubbing mix welding (FSW), laser bar welding (LBW) and beat current gas tungsten bend welding (PCGTAW) on weakness and consumption obstruction properties of magnesium amalgam. Exhaustion analyze was led utilizing servo pressure driven controlled weakness testing machine. The LBW joints showed higher exhaustion strength contrasted with FSW and PCGTAW joints. The development of fine grains around there, higher combination zone hardness, consistently circulated better encourages are the fundamental explanations behind unrivaled weakness execution of LBW joints.

Christian B. Fuller an etal [5],did exploratory work on ""Evolution of microstructure and mechanical properties in regularly developed 7050 and 7075 Al disintegration blend welds", to appropriate the going with results. The compound and mechanical properties of disintegration blend welded 7050-T7651 and 7075-T651 Al composites were examined as a component of room temperature (ordinary) developing for up to 67,920 h. During the extent of developing occasions inspected, get over flexible characteristics interminably extended, are at this point growing, with upgrades of 24% and 29% assessed for the 7050-T7651 and 7075-T651 The microstructural changes are discussed considering the disintegration properties as well.

Biswajit Parida etal [6], Worked on "Mechanical and Micro-essential Study of Friction Stir Welding of Al-blend", and appropriated the going with results. The proposed assessment will fuse tests related to the effect of FSW ideal cycle limit on weldability of Al composite.

S. Rajakumar etal [7], in their assessment paper "Effect of disintegration blend welding cooperation and gadget limits on strength properties of AA7075-T6 aluminum mix joints", appropriated their results on effect of crushing blend welding and instruments limits on strength properties. They cultivated a scouring blend welding equipment for driving tests. Their results fuse association of fortitude properties with measure limits and production of the blend mixture.

S.Rajakumar [8], has comeout with his assessment finding through his investigation paper "Upgrade and affectability examination of grinding blend welding cycle and mechanical assembly limits for joining AA1100 aluminum compound", which are given in the going with lines This paper bases on the improvement of precise relationship for the conjecture of unbending nature of contact blend welded AA 1100 aluminum mix joints. The exploratory piece of the assessment relies upon five level central composite plans of six (connection and contraption) limits. Headway of the model is done to help the flexibility using plan ace programming. An affectability examination is finished and taken a gander at the general impact of data limits on versatility to affirm the assessment botches on the potential gains of the weakness in evaluated limits. The results obtained show that made observational relationship can be applied to assess the sufficiency of cooperation and device limits for a given flexibility. The rotational speed is more sensitive than instrument hardness, followed by urgent force, shoulder distance across, pin broadness and welding speed.

S.Rajakumar etal[9], "expected Grain Size and Tensile Strength of Friction Stir Welded
Joints of AA7075-T6 Aluminum Alloy", and have dispersed their results which are summarized as given in the going with lines. This work reports accurate associations with expect grain size and unbending nature of contact blend welded (FSW) AA7075-T6 aluminum compound joints. Six-factor, five-level, central composite rotatable arrangement network is used to update the preliminary conditions. The observational associations are made by response surface way of thinking (RSM) merging mechanical assembly and communication limits. A straight backslide relationship is furthermore settled between grain size of weld piece and unbending nature of FSW joints.

S.Rajakumar etal [10], achieved expansive investigation work on predicting utilization hindrance of contact blend welded AA6061-T6 aluminum accomplice joints and disseminated there results on flexibility, hardness and disintegration rate.

S.Rajakumar etal [11], itemized their disclosures in their investigation paper, "Setting up exploratory associations with expect grain size and inflexibility of grinding blend welded AA 6061-T6 aluminum mixture joints". Their finding consolidate, AA 6061-T6 aluminum blend (Al-Mg-Si compound) has gathered wide affirmation in the production of light weight structures requiring a high express strength and incredible disintegration impediment.

III. ISSUES AND CHALLENGES IN FRICTION STIR WELDING PROCESS

A. An in depth study of estimation of strength values over a wide range is not reported in the literature.
B. The values reported in the literature are not comprehensive.
C. Estimation of strength values is mostly based on destructive testing experiments.
D. A typical optimization tool for selecting best process parameter is yet to be developed.
E. A correlation between process parameters and strength values may help in predicting the strength values of the FSW over a wide range.

IV. SCOPE AND OBJECTIVES OF PRESENT WORK

The scope of the present work is limited to developing a mathematical model for optimizing the process parameters of FSW for their strength. The correct choosing optimum parameters results in sound weldments with improved mechanical properties. Various sets of experiments are conducted and the strength values versus process parameters are noted down to develop the mathematical model for optimization.

V. FORMULATION OF THE PROBLEM

Choosing optimum process parameters of Friction stir welding results in sound weldments with improved mechanical properties. Hence an attempt in made in this paper to develop optimization of process parameters of FSW for improved mechanical properties. Hence the formulation of problem.

VI. METHODOLOGY OF PRESENT WORK

The methodology of present work has the following steps.

1) *Step 1:* Identification of process parameters and the metal / alloy to be friction stir welded.
2) *Step 2:* With varied process parameters, the welding is done.
3) *Step 3:* The strength of each weldments is estimated.
4) *Step 4:* A graphical mathematical model for optimization is developed and the combination of optimum parameters and the corresponding mechanical properties are arrived at.
5) *Step 5:* A manual check is made to assess the results of the optimization model.

VII. PRESENT WORK

Friction stir weldments of Mg alloys /CMs) are prepared, for different combinations of process parameters namely speed of in rpm, feed of tool in mm/min and axial force in KN. The corresponding UTs values in km/mm2 are noted. The mathematical model for optimization as explained in section 1.1 is obtained, and the optimum values for the process parameters are obtained. A manual check of the UTs for the optimum values of the parameters is made to assess the validity of the optimization technique used.

VIII. EXPERIMENTAL WORK

The experimental work is carried out through the following steps.

1) *Step 1:* The weld tool is given speeds from 950 rpm to 1500 rpm in steps of 50 rpm with a fixed feed and axial force. The corresponding UTs values are noted.
2) *Step 2:* For a feed variation from 0.37 mm/sec to 1.25 mm/sec and a fixed speed and axial force, the UTs values are noted.
3) *Step 3:* For a variation of axial force from 3kN to 4 kN in steps of 0.2 kN and a fixed speed and feed, the values of UTs are noted.
4) *Step 4:* A mathematical optimization model as explained in section 1.1 is developed and the values of optimum parameters are identified.

IX. RESULTS AND DISCUSSIONS

The results out of the present work are listed and discussed as shown below.

A. From the extensive literature review work, it is noticed that the strength values for different combinations of process parameters was not studies in depth and it has been addressed in the present work.
B. The behavioral and side constraints are identified and the objective functions are written.
C. A mathematical model gives the optimal values for the process parameters for max strength.

X. CONCLUSIONS

The major contribution of the present work is, development of a generalized optimization models for identification of values of process parameters for maximizing mechanical properties.

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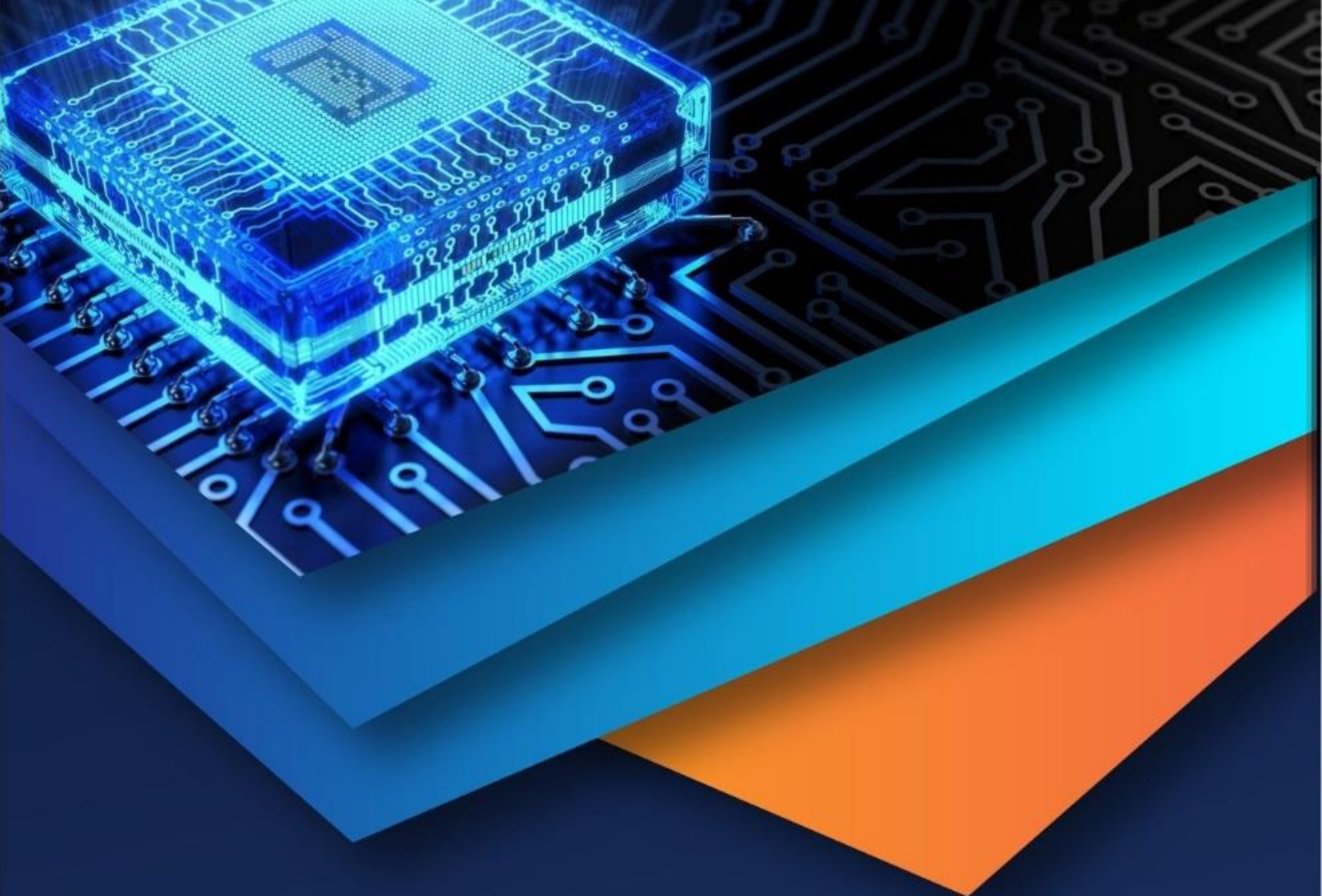

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