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A Stochastic Search Algorithm to Maximize Tensile Strength in a Molten Metal Spray Transfer Mode in Tig Welds

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Abstract

This study was performed to evaluate the environmental impacts arising from the life cycle of laptops by collecting and synthesizing data from life cycle assessment (LCA) studies. The research results shows the impacts of laptops include ozone depletion, potential global warming, acidification, eutrophication, carcinogenicity, respiratory effects, ecotoxicity and resource depletion. In particular, the production of laptop case, integrated circuits and flame retardants causes major impacts such as ecotoxicity, potential global warming and fossil fuels depletion. Results of LCA for the entire life cycle of the laptop Actina 244C10 shows the use phase accounts for 60% of the total impact and the production phase accounts for 37%. The transport and endlife treatment accounts for only 3% of the impacts. As for Dell Inspiron 2500 laptop, the most important impact is the production phase (account for 62-70%), remaining 30-38% of the impact is from use phase. In Vietnam, there are no specific policies related to the management of laptops, so the propaganda, collection and handling are limited

1. Introduction

The engineering materials that are mostly affected by hydrogen induced cracking are high carbon steels, the higher the strength of the steel the higher its vulnerability to hydrogen induced cracking. Careful experimental studies can help us to understand the interaction between hydrogen gas and the weld pool. [1].Defects caused by aluminum slags and inclusions was influenced by the presence of hydrogen which appeared in the form of clusters [2].The angular and linear weld distortion of mild steel which occurs in fillet welds can be reduced by the triangular heating and triangular cooling process.[3].The influence of tungsten inclusions on the fatigue of metal inert gas welding was investigated and discovered that by increasing the presence of the inclusions there was no significant change on the fatigue resistance[4].The application of genetic algorithm to reduce the transverse distortion of a v shaped angle joint was done ,the results showed that as the v angle increases the distortion also increases[5].Finite element method was used to analyse the angular distortion of a multi pass butt weld in gas metal arc welding, the results was presented in 2D and 3D simulations ,the 3D analysis possessed a higher reliability [6].A study on the interaction between the weld pool morphology, metallic microstructure and the pre weld operations and the effects on the strength of the weld. The result obtained revealed that material having the same values of thermal expansivity have a tendency been welded together easily [7]. In a dissimilar welding process it is important to understand the interaction between the mechanism of dissolution and diffusion of steel components [8]. A finite element model was developed to predict the thermal energy and angular distortion of manual metal arc welding, the results from the model is in reasonable agreements with the experimental data [9]. Welding speed has a significant effect on the hardness of the fusion zone of magnesium alloy and this was investigated using the laser tungsten inert gas welding technique. The results obtained showed that as the welding speed increases the hardness also increases [10].

2. Methodology

In this study 20 sets of welding experiments were performed to determine the ultimate tensile strength in a tungsten inert gas mild steel welded plate. The first step taken was to cut the mild steel coupons, sand paper and bevel the edges, thereafter the weld samples are cleaned to remove dust, rust and grease. A design of experiment was generated to help determine the total number of welding experiments to be performed. The mild steel samples were welded with the TIG welding technique.

2.1. Identification of Range of Input Parameters

The process parameters and their range of values range and level of the experimental variables used for statistical design of experiment are presented in Table 1.

. **Table 1: Range of input process parameters**

INPUT PARAMETERS	**Range and Levels of Input Variables**		
		Lower Range (-1)	**Upper Range (+1)**
Welding Current (Amp)	I	170	190
Welding Voltage (Volt)	V	21	25
Welding Speed (mm/s)	S	2	5
Gas flow rate (lit/min)	GFR	11	19

2.2. Method of Data Collection

In this study, the Central Composite Design was adopted. Central Composite design as stated earlier which apart from its three level factors has axial point (also known as star point), and this axial point increases the number of levels to five levels to give the experimental design flexibility and robustness. In Central Composite Design the minimum numbers of factors it can accommodate is two. The experimental data is shown in Table 2.

Table 2: Experimental data

I	V	S	GFR	UTS
140.00	22.00	2.00	17.00	655
200.00	20.00	2.63	15.00	780
140.00	18.00	2.00	13.00	880
160.00	20.00	2.63	15.00	615
160.00	20.00	2.63	15.00	615
140.00	22.00	3.25	13.00	560
160.00	20.00	2.63	11.00	870
120.00	20.00	2.63	15.00	720
180.00	22.00	3.25	17.00	876
160.00	20.00	3.88	15.00	455
160.00	20.00	2.63	15.00	615
160.00	20.00	2.63	15.00	615
180.00	18.00	2.00	17.00	645
140.00	18.00	3.25	17.00	655
160.00	20.00	2.63	15.00	615
180.00	18.00	3.25	13.00	719
180.00	22.00	2.00	13.00	892
140.00	18.00	2.00	17.00	880

140.00	18.00	3.25	13.00	580
160.00	20.00	2.63	19.00	830
140.00	22.00	3.25	17.00	560
160.00	20.00	1.38	15.00	576
140.00	22.00	2.00	13.00	850
160.00	20.00	2.63	15.00	576
180.00	22.00	2.00	17.00	645
180.00	18.00	2.00	13.00	766
160.00	16.00	2.63	15.00	770
160.00	24.00	2.63	15.00	830
180.00	18.00	3.25	17.00	719
180.00	22.00	3.25	13.00	876

2.3. Experimental procedure
Mild steel plate was used as the base material for the single-pass surface welding with a direct current of reverse polarity. The samples were grinded, sand cleaned and etched to get a fine edge because sample has to be free from grease and dirt.100 pieces of mild steel coupons was produced for this experiment using 100% argon gas as the shielding gas. In this process the tungsten non consumable electrode having diameter 3 mm was used alongside 2 mm diameter filler metal ER309Lthe responses were measured and recorded respectively.

2.4. Development of genetic algorithm model
The procedure for developing the genetic algorithm using Matlab can be summarized under the following,

1. Write the fitness function
2. Select the genetic algorithm optimization toolbox
3. Input all the necessary parameters and configurations to run the program
4. Run the optimization algorithm to obtain the optimal result.

   The Matlab software was used for this model development and the genetic algorithm, the steps taken in the genetic algorithm optimization is presented in a flow chart diagram shown in Figure 1.

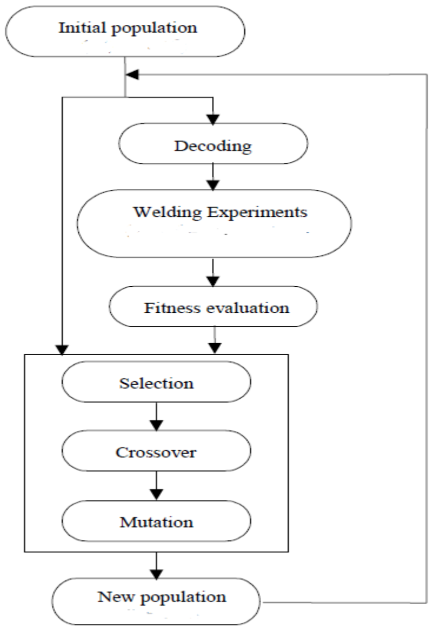

Figure 1: Optimization procedure using genetic algorithm.

.3. Results and Discussion

In this study, an attempt is made to develop a genetic algorithm model to explain the relationship between; current (I), voltage (V) welding speed and gas flow rate to maximize the ultimate tensile strength using the genetic algorithm.
The number of variables were four (current, voltage, weld speed and gas flow rate). The lower level factors for the current, voltage, weld speed and gas flow rate is given as 120, 16, 1.38 and 11 while the higher level factors are 200, 24, 3.88 and 19. population size (50), creation function (constraint dependent was selected), initial range was set at [-10; 10]. Mutation function was taken as adaptive feasibility. The time series plot is used to show how the responses are affected at different factor settings with time is presented in Figure 2.

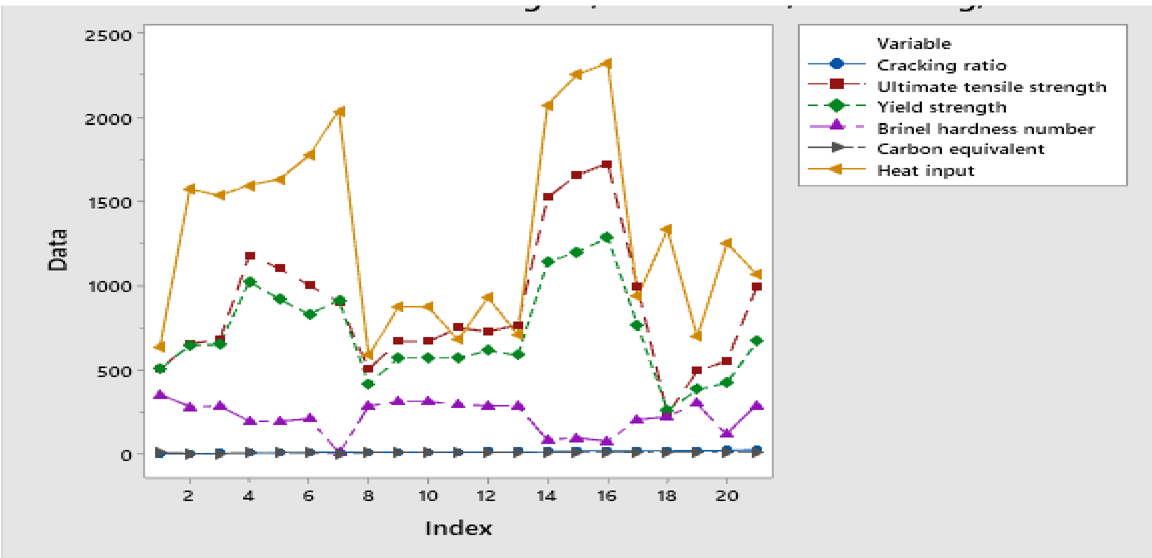

Figure 2: The time series plot for all the responses

To determine the number of generations attained before optimality distance vs generation plot is produced as shown in Figure 3.

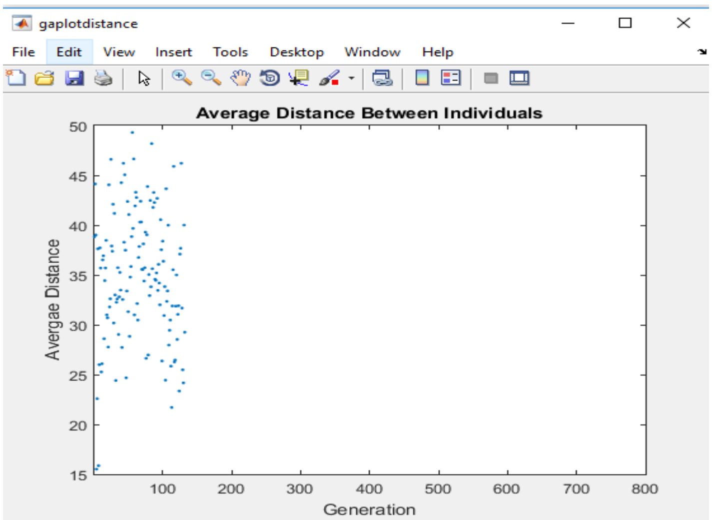

Figure 3: plot of number of generation vs average distance

To produce an accurate model the average distance measure between individuals must be determined, which is represented by a pareto distance plot as presented in Figure 4.

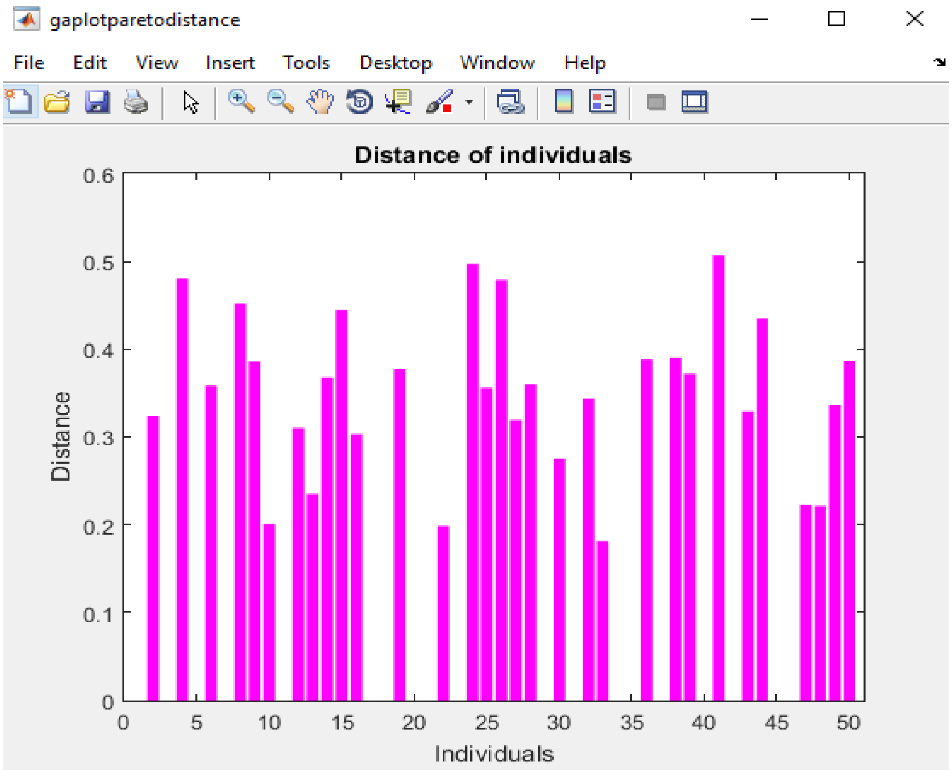

Figure 4: Average Pareto distance plot

Another statistical diagnostic needed for optimum model development is the Rank histogram plot which shows the fraction of individuals in each Pareto tier as shown in Figure 5.

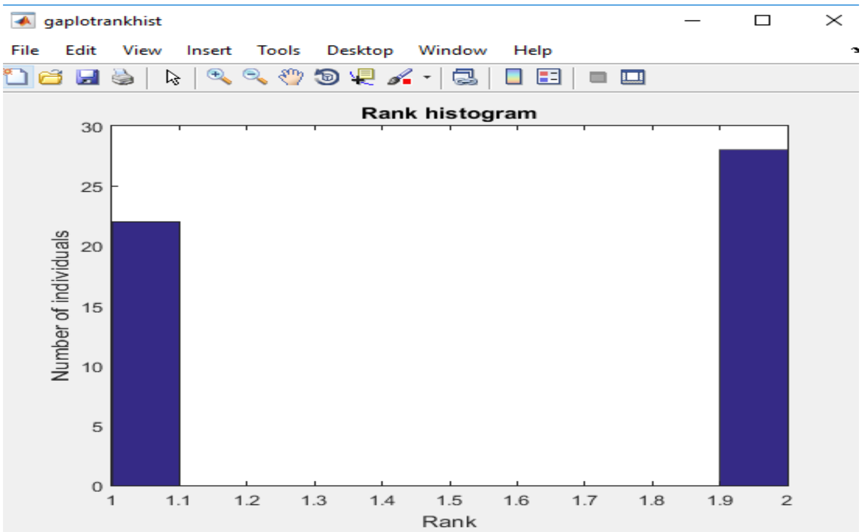

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Figure 5: Rank histogram plot showing the fraction of individuals.

To measure the integrity of the histogram a Score diversity plot is produce which shows the range of the target response. The score diversity plot is presented in Figure 6.

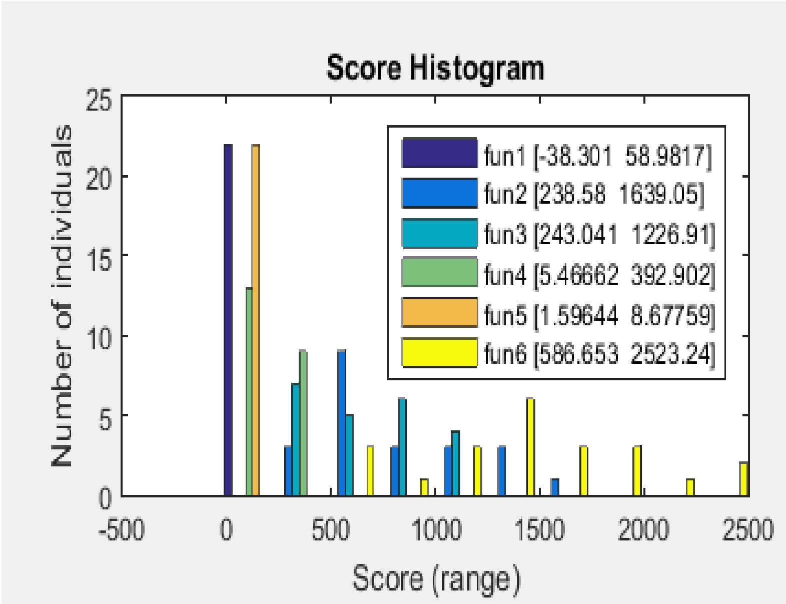

Figure 6: A Score diversity plot

To check for accuracy and reliability of the developed model a Pareto front plot required which shows the objective function values for all non-inferior solutions. The pareto front plot is presented in Figure 7.

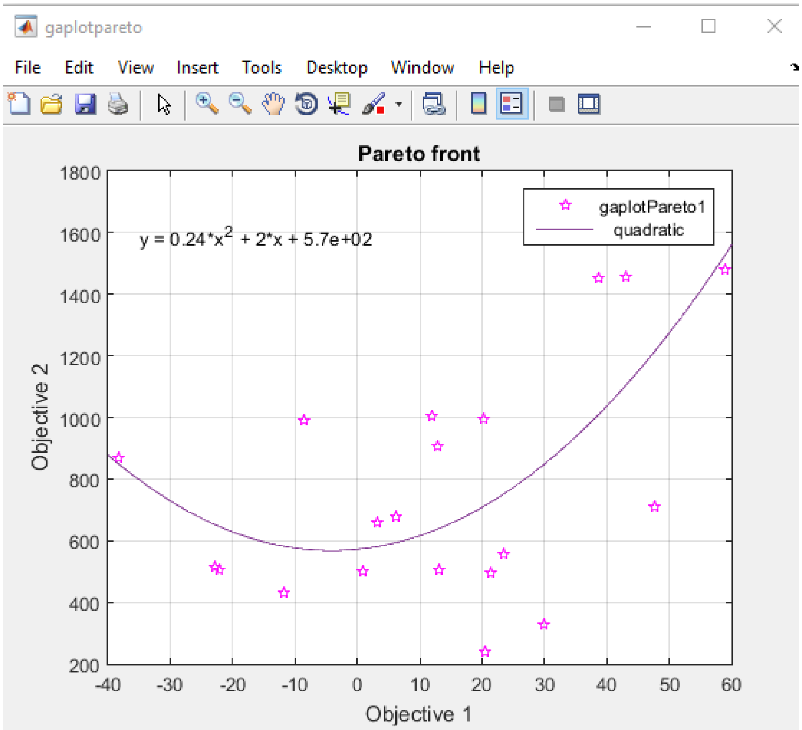

Figure 7: Pareto front plot showing objective function values

The numerical optimal solution obtained, fifty (50) results at the 133th generation of which Matlab selected 22 optimum results. Selection of the best optimum result is based on experiment.

Table 3: Optimal solutions for genetic algorithm model

S/N	current	Voltage	Welding speed	Gas flow rate	Ultimate tensile strength
1	143.0535	16.00063	3.879958	14.93288	502.9011
2	137.7131	23.52954	3.78686	11	658.801
3	143.0604	23.51977	3.879993	11	679.6307
4	195.8522	16	3.879993	18.9979	1183.589
5	195.7876	16	3.145009	18.99442	1104.433
6	195.8483	16.00006	2.588801	18.9979	1004.94
7	120	23.51782	1.40946	18.99975	905.3799
8	143.0677	17.67786	3.486072	15.00112	507.3252
9	124.2864	16.00006	3.879989	16.54268	670.6913
10	124.2864	16.00006	3.879989	16.54268	670.6908
11	143.0604	16.00038	3.484546	16.55049	752.5839
12	120	16.00063	3.78686	16.55049	730.043
13	137.7295	16.00038	3.484546	16.55049	768.3015
14	120.0018	17.68606	1.381968	11.00035	1527.309
15	124.2845	16.0004	1.38	11	1659.826
16	120	16	1.38	11	1729.459
17	120	16	3.145009	16.61104	994.459
18	120.0002	21.91202	3.879958	14.93288	238.5805
19	143.0604	17.68548	3.879993	16.55733	495.7152
20	120	21.91202	3.145009	16.55733	556.16
21	137.7131	16	3.879989	18.99442	998.081
22	137.7131	16	3.879989	18.99979	999.0707

4. Conclusion

The study has successfully applied the stochastic search algorithm to simulate tensile strength response in a molten transfer spray mode of TIG welds considering input factors such as current, voltage, gas flow rate and weld speed. The welding technique employed was the gas tungsten arc welding, using argon gas to produce mild steel coupons for the study. Genetic algorithm model was able to obtain optimum combination of the process parameters that can produce weld samples with maximum tensile strength in a welding process. The genetic algorithm model was developed and the adequacy was validated, the results predicted shows reasonable agreement to the experimental values.

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