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Electrical Discharge Machining Process by Metal Bonded Diamond Grinding Wheel

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ABSTRACT

One of the widely used processes is electrical discharge machining (EDM) for electrically conductive material in spite of on their strength, hardness and roughness. The amalgamation of grinding and EDM is defined as the Abrasive Electro Discharge Grinding (AEDG). In this work, the usual ANN does not deliver the desired output due to improper hidden layer and weights. So, we used Modified Ant Lion Optimization (MALO) algorithm to improve the ANN performance in terms of Metal Bonded Diamond Grinding Wheel (MBDGW) abrasive via ADEG process. Experimentally, the grit number, pulse-off time, pulse-on-time and peak current are given as the input. Different kinds of experimental analysis in terms of Material Removal Rate (MRR) and Surface Roughness (SR) are carried out to evaluate the performance of proposed work. Finally, the proposed MALO-ANN method demonstrated better Abrasive Electro Discharge Grinding procedure in terms of Metal Bonded Diamond Grinding Wheel (MBDGW).

Keywords: Metal Bonded Diamond Grinding Wheel, Boron Carbide, Artificial Neural Network, Modified Ant Lion Optimization algorithm, Material Removal Rate and Surface Roughness.

I. INTRODUCTION

Nowadays, the complex to machine materials and incessant accessibility growth are increased day by day. By combining various physical events on the materials achieves the technological development of machining process. These materials are adopted and explored with the usage of different non-traditional approaches [1]. One of the widely used processes is electrical discharge machining (EDM) for electrically conductive material in spite of on their strength, hardness and roughness [11]. The thermal energy and electrical energy is combined in the presence of erosion controlled via electrical spark series generation during EDM process. Drilling, turning, milling, grinding and so on the removal of materials via chip formation, micro chipping and mechanical abrasion are the traditional procedures. The material is highly machined brittle due to the high hardness that is above 500 HB [2, 14]. The forces such as drilling, shaping, milling, turning and etc in the conventional material removal procedures are applied on the work piece by using the cutting instrument that eliminates the additional materials [15].

The combinations of electrical, thermal and chemical energy remove the materials instead of sharp cutting tools during NTM process. Moreover, the material tool must contain huge hardness than work material and it is not mandatory. The tools never create any contact with the work piece in some of the NTM processes [3]. The removal of material from the work piece surface by the representation of particle minutes when occurring dimensional accuracy and senior surface smoothness [4]. Based on energy deployment, these procedures are categorized into different processes namely hybrid machining, mechanical, chemical, electro thermal process and electro chemical process for material removal. The amalgamation of grinding and EDM is defined as the Abrasive Electro Discharge Grinding (AEDG). The combinations of electrical, thermal and chemical energy remove the materials instead of sharp cutting tools during NTM process. Based on the AEDG process, the graphite and metallic electrode are utilized in the AEDG process [5, 20].

The electro discharge grinding procedure is carried out by using the graphite or metallic electrode in the AEDG, which is processed due to the replacement of metallic bond grinding wheel. The process conditions scheme presents the machining process. Different kinds of advanced conductive materials such as ceramics, composite and carbide are widely used for the manufacturing of surgical apparatus, aerospace parts, automotive parts and mould. The fragile samples are machined without damage because of non-contact surface between the tool and specimen [6]. During machining process, the effective method and lower grinding wheel wear are the essential benefits for grinding wheel dressing. The metal composites, sintered carbides, engineering ceramics, super-hard materials to increase the performance measure of AEDG process.

II. RELATED WORKS

The novel abrasive electric discharge grinding was proposed by Kozak et al. [7]. The machining difficult to cut materials with the performance characteristics is investigated. The machining process including conventional grinding, AEDG process and conventional grinding is allowed via the developed machining systems. The self addressing process in AEDG is analyzed by the initial paper illustrates the thermal model. Furthermore, the adaptive control systems with the modular abrasive lector discharge grinding machines are analyzed in the second part. During machining of cutting tool, the general performance of machining system characteristics are achieved. Shrivastava et al. [8] investigated the performance of cubic boron nitride (CBN) and tat analysis the characteristics of parametric analysis model. During high steel speed, the most important quality behavior is surface roughness. For SR modeling, the Artificial Neural Network (ANN) was introduced. During single objective SR optimization, the combination of Genetic algorithm (GA) with ANN delivers better SR results. Based on electrical discharge CBN grinding, the abrasive size of grinding wheel causes the surface roughness. For SR, the electrical parameters namely pulse on time and peak current are effectively chosen. The introduced ANN representation for SR is determined adequate and reliable with negligible prediction error.

III. AUTOMATIC ELECTRICAL DISCHARGE GRINDING (AEDG) PROCEDURE ANALYSIS

In this section, we studied the AEDG process with its experimental setup. Thereafter certain number of operations, the metal bounded diamond grinding wheel looses their cutting capability during grinding process [21]. Therefore, the wheel of frequent re-dressing become imperative and it resume the effective grinding process. The metal bounded grinding wheels of conventional dressing methods guides to severe wear of the tool and it more time consuming one. Where, the electrical discharge (ED) erodes the wheel and work piece of MMC (Boron Carbide or Aluminum Silicon) in which the self dressing procedure was widely carried out by the important benefit of AEDG [23]. For the dressing wheel, there is not required to interrupt machining because of continuous dressing wheel. The productive machining time is saved and the Automatic Electrical Discharge Grinding (AEDG) is as illustrated in Fig 1.

Fig 1: Schematic diagram of Metal Bonded Diamond Grinding Wheel

3.1 Material Matrix Composite (MMC) fabrication:

At 800ºC temperature, the graphite crucible of a tiling oil-fired melts the aluminum ingots. Based on the present temperature, the melting alloy with the diesel is act as a fuel for oil-fired furnace. To kept the alloy more than three hours at the present temperature [26]. The oil-fired furnace cap prevents the molten metal oxidation that has been maintained inside the furnace. At the similar period, the pre-heat may reinforce 10% silicon carbide particulate with the fraction of weight. The adsorption gases are assisted also the surface impurities are removed. Thereafter, the particles of silicon carbide frequently tend towards the molten metal through small amount and long handle spoon. Based on the requirement of blower, the oil fired furnace with flame intensity is regulated. From the critical to ladle, the composite mixtures are collected. The sand mould is obtained and fed to the runner system. For approximately one hour, the composite mixture is permitted to solidify it [25]. Finally, the desired casting component is obtained based on broken mould. The machined cylindrical shape is received via casted metal matrix.

IV. PROPOSED METHODOLOGY

In this section, we proposed MALO-ANN method for optimal Surface Roughness and Material Removal rates based on Metal Bonded Diamond Grinding Wheel (MBDGW) abrasive via ADEG process.

4.1 Artificial Neural Network:

ANN is the important part of artificial intelligence (AI). Now-a-days, the AI applications are more essential in the field of engineering. Most of the researchers were used ANN methods because of its accuracy and better performance results. In manufacturing science, number of researchers was used back-propagation model to predict the process performance. Thereafter the neural architecture of brain with the ANN is the simple electronic devices. The complex applications such as pattern recognition, identification of system and optimization are easily solved using the ANN [27]. Mathematical mapping evaluates the ANN that consist of input layer, hidden layer and output layers are multiplied by weights. The information is processed by neurons of ANN. The training algorithms, activation function and it structure categorizes the neural network (NN) and each NN has its own input-output individuality [28]. The ANN model is used for the performance analysis of Metal Bonded Diamond Grinding Wheel and MRR and SR in AEDG process were analyzed. The summing function is depicted as below:

$$N_R = \sum_{R=1}^{M} W_{pR} Y_R + a_p \tag{1}$$

The net or total input is N_R. Based on the forward layer, the number of input to the R_{th} neuron is M. In the forward layer, the connection to the p^{th} neuron weight is W_{pR}. The input with the R^{th} neuron in the preceding layer is Y_R and the bias function is a_p. The activation function processing the net input that produces the output as O_R. The trial and error is performing the activation function sections. Based on the hidden and output layer, various kinds of activation functions are chosen and it delivers minimum mean square error (MSE). Often prefers the network training in the calculation of connection weights. Then apply the quasi random weights and the gradient decent method delivers few convergence values. Fig 2 explains the ANN structure utilized in this work. The grit number, pulse-off time, pulse-on-time and peak current are given as the input. Finally, the MMR and SR rate is obtained as the output.

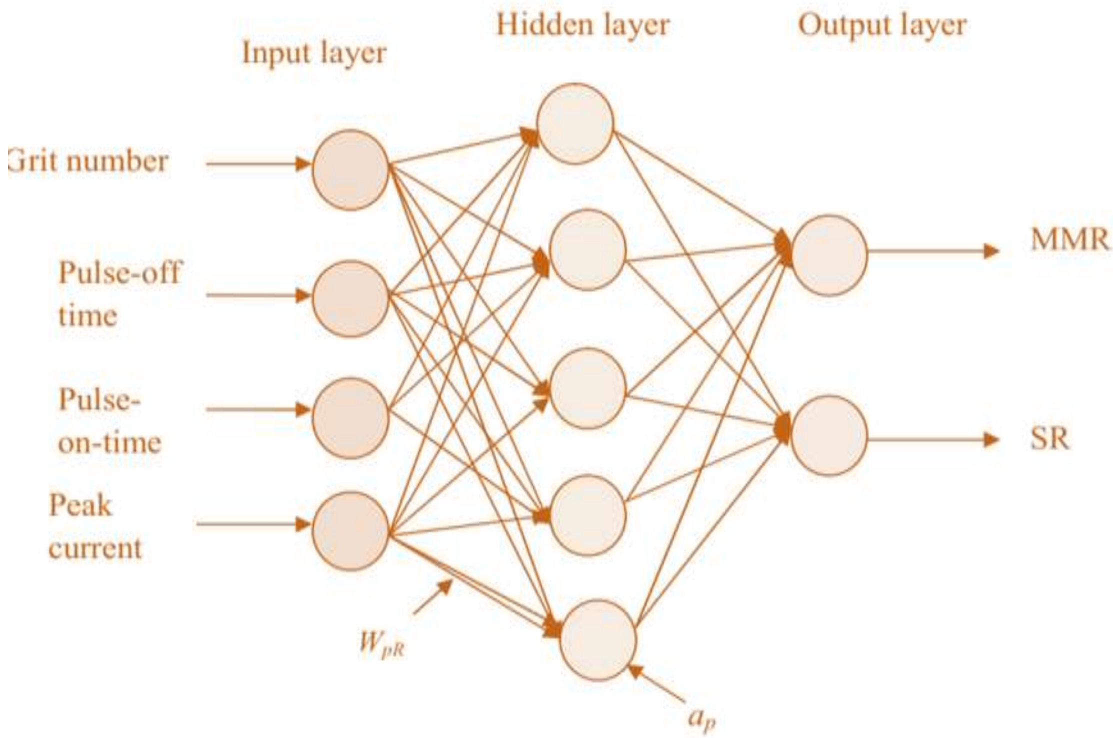

Fig 2: ANN model used in this study

4.2 ANN based MALO algorithm:

In this work, we used ANN structure for the performance analysis of Metal Bonded Diamond Grinding Wheel (MBDGW) abrasive via ADEG process. But, the normal ANN does not deliver the desired output due to improper hidden layer and weights. So, we used Modified Ant Lion Optimization (MALO) algorithm to improve the ANN performance in terms of Metal Bonded Diamond Grinding Wheel (MBDGW) abrasive via ADEG process [17].

4.3 *Performance Evaluation*

Bonded Diamond Grinding Wheel 12A2-45^{o}AC6 of 100/80M1-01-4 with a particular grade/ type of MMC. The ELEKTRA PULS die sinking spark erosion machine attaches and develops the electric discharge diamond grinding setup. The metal bounded grinding wheel is used to hold the setup that contains vertical shaft. The arrangement of pulley and belt rotates the DC motor via shaft. This experiment is conducted to select the high speed steel disc [30]. The input parameters including Grit number, Pulse-off time (μs), Pulse-on-time (μs) and Peak current (A) are considered with three levels. The input parameters based on three levels are depicted in Table 1.

Table 1: Input parameters based on three levels

Input parameters	Different levels		
	Level-1	***Level-2***	***Level-3***
Grit number	80	120	240
Pulse-off time (μs)	40	60	80
Pulse-on-time (μs)	100	150	200
Peak current (A)	2	4	6

In this work, the proposed MALO-ANN method is introduced to predict the optimal material removal rate (MRR) and Surface roughness (SR) from Metal Bonded Diamond Grinding Wheel via AEDG process. There are 6050dat set are used to simulate the ANN model.

State-of-art comparison results:

Fig 3 illustrates the states-of-art comparison performance results. In this experiment, we have chosen the meta-heuristic algorithms including proposed MALO with existing Particle Swarm Optimization (PSO), Genetic Algorithm (GA), Grey Wolf Optimization (GWO) and Ant Lion Optimization (ALO) algorithms. Based on Fig 9, the PSO, GA, GWO, ALO and proposed MALO provides 34%, 29%, 49%, 58% and 89% convergence performance results. Anyway, the proposed the proposed MALO delivers higher convergence performances and better efficiency than other existing approaches.

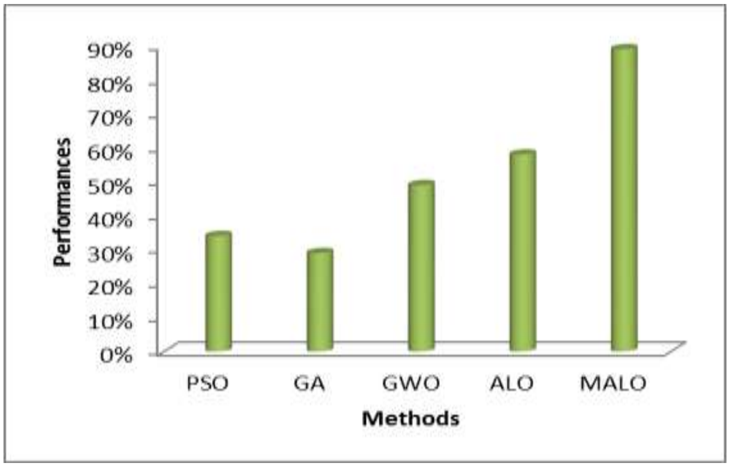

Fig 3: State-of-art comparison of convergence performance

The state-of art- comparison of material removal rate (MMR) is investigated in Fig 9. In this experiment, we have chosen Artificial Neural Network (ANN) [6], Genetic Algorithm (GA) [8], Particle Swarm Optimization based Electric Discharge Machining (PSO-EDM) [15], Artificial Neural Network based Non Dominated Sorting Genetic Algorithm (ANN-NGSA) and proposed Modified Ant Lion Optimization based Artificial Neural Network model (MALO-ANN) [28]. Anyway, the proposed MALO-ANN delivers low material removal rate than other existing methods. Hence, the proposed MALO-ANN algorithm provides smaller amount of material removal rate during Metal Bonded Diamond Grinding Wheel process.

V. CONCLUSION

This paper proposed Modified Ant Lion Optimization based Artificial Neural Network (MALO-ANN) method. We used Metal Bonded Diamond Grinding Wheel 12A2-45ºAC6 of 100/80M1-01-4 with a particular grade/type of MMC (Boron Carbide and Aluminum Silicon). Experimentally, grit number, pulse-off time, pulse-on-time and peak current are taken as the input with three levels. The validation results of both MAE and MPE are higher than training data and testing data in terms of MRR and SR. The proposed MALO delivers higher convergence performances and better efficiency than other existing approaches such as PSO, GA, GWO and ALO. Finally, the proposed MALO-ANN method demonstrated better Abrasive Electro Discharge Grinding procedure in terms of Metal Bonded Diamond Grinding Wheel (MBDGW).

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