Chapter 4
Nature–Inspired Metaheuristic Approach for Multi–Objective Optimization During WEDM Process

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ABSTRACT
In this research paper Wire–Electric Discharge Machining (WEDM) is applied to machine AISI–D3 material in order to measure the performance of multi–objective responses like high material removal rate and low roughness. This contradictory objective is accomplished by the control parameters like Pulse on Time (Ton), Pulse off Time (Toff), Wire Feed (W/Feed) and Wire Tension (W/Ten) employing brass wire. Here the orthogonal array is used to developed 625 parametric combinations. The optimization of the contradictory responses is carried out in a metaheuristic environment. Artificial Neural Network is employed to train and validate the experimental result. Primarily the individual responses are optimized by employing Firefly algorithm (FA). This is followed by a multi–objective optimization through Genetic algorithm (GA) approach. As the results obtained through GA infer a domain of solutions, therefore Grey Relation Analysis (GRA) is applied where the weights are considered through Fuzzy set theory to ascertain the best parametric combination amongst the set of feasible alternatives.

INTRODUCTION
Our advanced lifestyle has rapidly improved by the quick development of various technology. Thus, the possibility to achieve an effective solution for real–world based problems is very high. These days, it is also visible that mathematical dynamics of the related solution approaches are commonly based on nature dynamics. From this point of view, nature has an incredible role on approaching the solutions and design mathematical structure for developing effective scientific, computational methods or techniques.

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Also, the connection in between nature and science has established a new research approach to solve real life problem. Many nature-inspired methods and algorithm that can be employed in the context of intelligent solution approach like cooperative characteristics by the swarms like a firefly, bat, bee etc. Due to their great possibility on developing effective algorithmic solution way, nature-inspired techniques have a huge effect on Artificial Intelligence based studies. The main advantages of this methods are that it can also be used with another Artificial Intelligence algorithm to form hybrid methodologies.

Alternatively, it is also possible to classify such nature-inspired techniques based on some mechanisms inspired by the theory of Evaluation. Genetic Algorithm is one of this evolutionary technique which is based on the theory of survival of the fittest by Darwin.

Traditional machining served the necessities of industries over the eras. But new advanced work materials, as well as the geometric design of products and components are putting a lot of pressure on the capabilities of traditional machining processes to manufacture the components with desired tolerance economically. This has led to the growth and founding of Non-Traditional Machining processes in industries as efficient and economic alternatives to conventional ones. Wire Electrical Discharge Machining (WEDM) is one such non-conventional, thermo-electric machining process which has an important role in high-precision and high-performance manufacturing industries due to its capability of accurate and efficient machining of parts with varying hardness or complex shapes and sharp edges of the workpiece. In WEDM material removal takes place by controlled erosion of the electrically conducting material. The material removal process governed by a series of discrete sparks between an anode workpiece which is immersed in a dielectric liquid medium and continuously feeding cathode wire through the workpiece controlled by a microprocessor. This electric discharge melts and vaporizes small amounts of the work material, and the removed material is flushed away by the flowing dielectric liquid. As the tool wire and the workpiece does not make direct contact during machining, so there is no machining stress, chatter and vibration. Therefore, this machining process can be utilized in machining of conductive material having low machinability and high temperature strength resistance.

In order to achieve high quality, high process safety, minimal manufacturing cost and lowest possible machining time the manufacturing process parameters have to choose in an optimized way. The photograph of WEDM setup is illustrated in Figure 1.

Figure 1. Machining setup of WEDM
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