International Journal of
Emerging Research in Management &Technology
ISSN: 2278-9359 (Volume-5, Issue-2)

Research Article | February 2016

A Review on Parametric Optimization of Electric Discharge Machine

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Abstract—

An optimization is a method of making a design as effective and viable as possible. It includes Maximizing or minimizing some function relative to some set which often represent a range of choices available in a certain situation. The function allows comparison of the different choices for determining which might be best solution. Electrical discharge machining (EDM) is a non-traditional machining technique which provides the means to fabricate highly complex geometrical forms in hardest and toughest materials. As a result, EDM is widely applied throughout the modern metal-working industry for the fabrication of high-precision dies. In the EDM process, material is removed from the workpiece by generating high-frequency electrical sparks through a thin dielectric layer between the electrode and the workpiece material. This paper reviews the various optimization techniques which provide the best and efficient solution considering various machining parameters which govern the process.

Keywords— Electric Discharge Machining (EDM), Machining parameters, Optimization Techniques.

I. INTRODUCTION

Electric Discharge Machining (EDM) is a thermo–electric process in which material removal takes place through the process of controlled spark erosion. Materials with high hardness and high strength such as composites and ceramics can be machined easily with close precision and surface finish [1]. As EDM is a non-contact process, it generates no cutting forces, permitting the production of small and fragile pieces. The electrode is moved towards the work piece until the gap is small enough so that the impressed voltage is great enough to ionize the dielectric. Short duration discharges are generated in a liquid dielectric gap, which separates tool and work piece. The material is removed with the erosive effect of the electrical discharges from tool and work piece by flushing dielectric through the interface [2]. Now various types of EDM with proper control of parameters has effectively been the backbone of machining especially tool and die machining. The various optimization methodologies adopted for providing an effective solution and mathematically model the parameters are discussed in this paper.

II. FUZZY LOGIC

Fuzzy logic has great capability towards decision-making, human common sense reasoning, and other aspects of human cognition. It overcomes the limitations of classic logical systems, which induce inherent limitations on demonstration of inaccurate concepts. Ambiguity in the coefficients and constraints may be naturally modeled by fuzzy logic. Modeling by fuzzy logic opens up a new way to optimize cutting conditions and also tool selection importance of integration between fuzzy and Artificial Neural based technique for effective process control in manufacturing. Several applications of fuzzy set theory-based modeling of metal cutting processes are reported in the literature [3].

Many linguistic terms - words can be converted into a fuzzy set. For example, the "high feed" can be represented by a fuzzy set in which the feed values more than an upper threshold value. The value can be assigned a membership grade 1 and those lower than a lower threshold value can be assigned a grade 0. Between lower and upper threshold, the feed values can have a gradual variation of membership grades from 0 to 1. Based on each rule, inference can be drawn on output grade and membership value. Inferences obtained from various rules are combined to arrive at a final decision. The membership values thus obtained are evaluated using various techniques to obtain true value.

III. GENETIC ALGORITHM

An Genetic algorithm is based on mechanics of natural selection and natural genetics, which are more robust and more likely to locate global optimum. It is because of this feature that GA goes through solution space starting from a group of points and not from a single point. It incorporates the "survival of the fittest" philosophy [4].

In this optimization technique, a point in search space is represented by binary or decimal numbers, known as string or chromosome. Each chromosome is assigned a fitness value that indicates how closely it satisfies the desired objective. A set of chromosomes is called population. A population is operated by three fundamental operations of reproduction (to replace the population with large number of good strings having high fitness values), crossover (for producing new chromosomes by combining the various pairs of parent chromosomes in the population) and mutation (for random modification of parent chromosomes). A sequence of these operations constitute one generation. The process repeats till the system converges to the required accuracy after many generations. The genetic algorithms have been found very useful in finding out the global minimum [5].

IV. TAGUCHI METHOD

Taguchi methods represent a new philosophy in which quality is measured by the deviation of a functional characteristic from its target value. uncontrolled variables called noise can cause such deviations resulting in loss of quality. Taguchi methods seek to remove the effect of noises. Taguchi described that quality engineering encompasses all stages of process development, system design, parameter design, and tolerance design. Taguchi's contribution to quality engineering has been far ranging[6].

Taguchi method is usually appreciated for its distribution-free and orthogonal array design and it provides a considerable reduction of time and resource needed to determine important factors affecting operations with simultaneous improvement of quality and cost of manufacturing. The concept of Taguchi's robust design is based on designing a product or process in such a way so as to make its performance less sensitive to variation due to uncontrolled or noise variables which are not economical to control[7,8].

V. SIMULATED ANNEALING

Simulated annealing (SA) Is a generic probability metaheuristic technique which is based on the cooling of metal during annealing, a technique involving heating and controlled cooling of a material to increase the size of its crystals and reduce their defects. It is used for the global optimization problem of applied mathematics, namely locating a good approximation to the global minimum of a given function in a large search space. For certain problems, simulated annealing may be more effective because the main goal is merely to find an acceptably good solution in a fixed amount of time, rather than the best possible solution in a larger time period [5].

VI. ANT COLONY OPTIMIZATION

Ant colony optimization (ACO) is a population-based heuristic that can be used to find approximate solutions to difficult optimization problems. In ACO, a set of software agents called artificial ants search for good solutions to a given optimization problem. To apply ACO, the optimization problem is transformed into the problem of finding the best path on a weighted graph. Near-blind ants are establishing the shortest route from their nest to the food source and back. These ants secrete a substance, called pheromone, and use its trails as medium of communicating information. The probability of the trail being followed by other ants is enhanced by further deposition of pheromone by other ants moving on that same path. This cooperative behaviour of ants inspired the new computational paradigm for optimizing real life systems, which are suited for solving large scale problems with a lot of different data. Solutions are chosen probabilistically based on pheromone level. Thus, this operation forces the algorithm to search in the area of better solutions. The aim of pheromone update is to increase the pheromone values associated with good or promising solutions and decrease those that are associated with bad ones [5,9].

VII. RESPONSE SURFACE METHODOLOGY

Response surface methodology (RSM) determines the relationship between various factors and responses. RSM also ascertains the significance of these parameters on the responses. It is a collection of mathematical and statistical techniques for empirical model building. By careful design of experiments, the objective is to optimize a response (output variable) which is influenced by several independent variables (input variables). There are two main types of response surface designs- Central Composite designs and Box-Behnken designs. Central Composite designs can fit a full quadratic model. They are often used when the design plan calls for sequential experimentation because these designs can include information from a correctly planned factorial experiment. While Box-Behnken designs usually have fewer design points than central composite designs, thus, they are less expensive to run with the same number of factors. They can efficiently estimate the first- and second-order coefficients; however, they can't include runs from a factorial experiment. Box-Behnken designs always have 3 levels per factor, unlike central composite designs which can have up to 5. Also unlike central composite designs, Box-Behnken designs never include runs where all factors are at their extreme setting, such as all of the low settings [10].

VIII. SCATTER SEARCH TECHNIQUE

Scatter search (SS) technique originates from strategies for combining decision rules and surrogate constraints. SS is completely generalized and problem-independent since it has no restrictive assumptions about objective function, parameter set and constraint set. It can be easily modified to optimize machining operation under various economic criteria and numerous practical constraints. It can obtain near-optimal solutions within reasonable execution time on PC. Potentially, it can be extended as an on-line quality control strategy for optimizing machining parameters based on signals from sensors [11].

IX. FLOWCHART

The flowchart of the steps involved in parametric optimization as shown in figure 1.

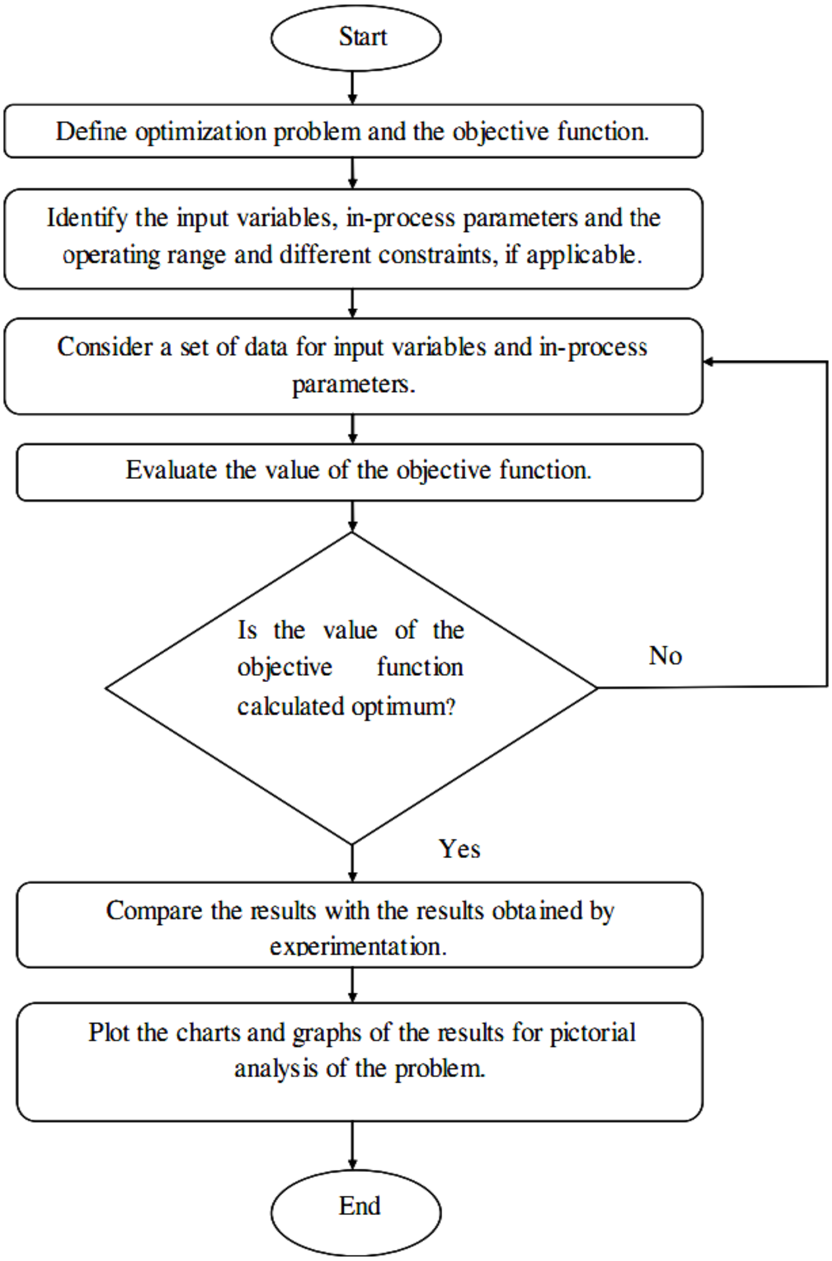

Figure 1: Steps in Optimization Process [11]

X. CONCLUSION

A systematic approach of modeling and determination of optimal machining conditions has shown an interesting potential in product/process improvement of metal cutting operations. This paper has presented a review of the optimization techniques in machining of hardened metals through Electric Discharge Machine. In turning process, the Taguchi approach proves to be an efficient tools for controlling the effect of Metal Removal Rate and surface roughness. Response surface methodology (RSM) presented the desired criteria optimization for determining the relationship between the various machining parameters. Genetic algorithm (GA) is used to identify the constants of the proposed model; the result is optimizing the predicting of tool wear rate and improving surface roughness. Moreover it attempts to provide the user with flexibility to adopt suitable techniques based on their intrinsic potential.

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