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"A REVIEW ON OPTIMIZATION OF MATERIAL REMOVAL RATE FOR EDM MACHINE PROCESS DURING PRODUCTION OF IMPLANTS MATERIAL"

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ABSTRACT

The investigation on conventional and advanced machining of biocompatible materials has demonstrated the potential to produce a variety of biocompatible material specifications which can be used as implants. These machining processes can improve the quality of machined biocompatible materials and at the end produce implants of complex shape from metals, polymers, ceramics, and composites. The various machining techniques have an effect on the physical properties of the implants which may have a significant influence on the biocompatibility.From this research it has observed that MRR is affected significantly by pulse on time. And here MRR optimization error rate was reduced to 3% . Optimization of EDM factors and parameters can improve the performance as well as reduces the environmental impact and production cost.

Key Words: *MRR, biocompatible material, EDM, error, metals, machining.*

I. INTRODUCTION

Biomedical Implant Devices

An implant is a medical device manufactured to replace a missing biological structure, to support a damaged biological structure or to improve an existing biological structure. Medical implants are artificial devices, as opposed to a transplant, which is transplanted biomedical tissue. The surface of the implants that come into contact with the body can be made with a biomedical material such as titanium, silicone or apatite, whichever is more functional [1]. In some cases, the systems contain electronic components, e.g. artificial pacemakers and cochlear implants. Some implants are bioactive, such assubcutaneous drug delivery devices in the form of implantable pills or drug eluting stents. Some of the examples are given in figure 1.1

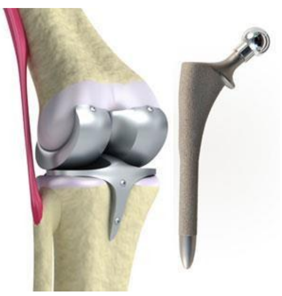

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Figure 1.1: Biomedical Implant Devices

II. LITERATURE REVIEW

Finding an optimized set of inputs to produce adequate results has been a difficult and daunting task for researchers for many years. The effects of EDM process parameters on processing responses or performance have been studied by many researchers. However, the processing services and the responses considered, the relationship between the different process parameters and the processing responses and the optimization techniques used by the different researchers are very different. Several techniques have been used by various researchers to model the mathematical relationship between processing responses and process parameters. However, the most used and preferred for the EDM process is the second order polynomial model or the response surface model (RSM).

The above literature review shows that traditional methodssuch as graphicssolutions technology, Taguchi, Topsis etc. they were mainly used for the parametric optimization of the EDM process. However, traditional methods are limited to a wide range of problem areas. The complexity of the optimization problem further limits the application of traditional optimization methods.The use of non-traditional methodssuch as GA (Genetic Algorithm) offers an almost optimal solution. In order to overcome the drawbacks of traditional optimization techniques and non-traditional methodssuch as GA, PSO, ABC (Ant Bee Colony) and other heuristic and evolutionary optimization techniques, they are used by the scientific community. The evolutionary optimization algorithm is based on biological genetics. These optimization techniques are more robust than conventional techniques because instead of functional derivatives, fitness information is used by evolutionary optimization techniques. We therefore tryto use these optimization techniques to arrive at a more precise solution.

Aharwal et al. [2018] optimized the machining parameters on the electric discharge machine (EDM) using AlSiC as the workpiece and pure copper as the electrode. The processing parameters examined in this thesis are the material removal rate (MRR) and the surface roughness. The control parameters used are discharge voltage (v), discharge current (Ip), pulse charge factor (Tau), pulse activation time (ton). The Taguchi technique (L16b orthogonal matrix) was used for the experimental design and the genetic algorithm for optimization.Material removal rate analysis provides optimal values when the current is high and the voltage is low, while the surface roughness is best when both are low.[1]

Mohan et al [2004] investigated the influence of the rotating tube electrode on the machining properties of Sic / 6025 aluminum composite materials. In hisstudy, he found the positive effect of peak current on surface roughness (SR), rate of material removal (MRR) and tool wear rate (TWR). TWR, MRR and SR were greater when treated with positive versus negative polarity. The pulse duration was inversely proportional to TWR, MRR and SR. The speed and diameter of the electrode hole had a great influence on the material removal rate and the decrease in SR and TWR. The genetic algorithm was used to achieve an optimal stock removal rate, better surface quality and minimal tool wear.[2]

Khan et al [2008] evaluated tool wear along the tool length versus wear along its crosssection. The wear of brass and copper tools increased with increasing current and voltage, but the wear along its crosssection was greater than

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that along its length. As the current wear rate increases, this has also increased, demonstrating that with increasing current, both material removal and tool wear increase, but tool wear increases relatively more. The highest wear rate was found for steel when using brass as the tool electrode. A faster material removal rate was observed using a brass electrode on an aluminum part. When machining steel using a copper electrode, the material removal rate was low due to the low thermal conductivity of the workpiece.[3]

Muttamara et al [2009] compared the effect of creating conductive layers on aluminum oxide using graphite, copper and copper infiltrated graphite according to the properties of EDM. When copper infiltrated graphite was used in the processing of 95% pure alumina, the material removalrate was much higher and the tool wear rate was lower than that of graphite and copper electrode. The material removal rate was increased by 60% using a straight polarity graphite electrode, while the material removal rate was increased by 80% using copper infiltrated graphite with straight polarity and the same conditions. No copper elements were found on the conductive layers with graphite and copper infiltrated graphite, while the results were investigated by energydispersive spectroscopy (EDS). Using straight polarity copper infiltrated graphite, a surface roughness of 25 µm was achieved.[4]

Priyaranjan et al [2014] evaluated that when machining AISI 329 stainlesssteel, good machinabilityand better hole quality are achieved by using copper as a tool electrode compared to the brass electrode. Brass electrodes wear out faster than copper electrodes due to their low melting point, high specific electrical resistance, and low thermal conductivity.[5]

Chan et al. [2015] presented an approach for optimizing feed rate based on material removal rate (MRR). Considering a toolpath with predefined feed rates, raw material geometry and cutter shape, the MRR histogram can be calculated efficiently with very fine resolution using a GPU- based geometric modeling core. Based on the evaluation of the finest MRR histogram, error- controlled splitting algorithms are developed to segment the toolpath step-by-step into a user- defined number of sub-regions. Different sub-intervals are assigned to different feed rates, so that an almost constant MRR is achieved while the shape of the given toolpath remains unchanged. Experimental tests on real examples confirm the effectiveness of this method.[6]

Khandare et al. [2009] claimed that the EDM process relies on the thermoelectric energy between the workpiece and an electrode. Pulse discharge occurs in a small gap between the workpiece and the electrode and removes unwanted material from the base metal by melting and evaporation. The electrode and workpiece must have electrical conductivity to generate the spark. Parts of aerospace, automotive and surgical components can be machined by erosion. The correct selection of production conditions is one of the most important aspects to consider when processing lead plates with a plumb line (EDM) of conductive materials, since these conditions must determine such important properties.which: surface roughness and speed of material removal, among others. The author examined the influence of current (I), pulse time (ti) and different materials factors on the listed technological properties. As a result, mathematical models are obtained using the Taguchi Design of Experiments (DOE) technique to select the optimal machining conditions for the finishing steps. This is done with only a small number of experiments.[7]

Agrawal et al. [2016] discussed that metal matrix composites (MMCs) pose challenges to processing with conventional methods due to their superior mechanical properties. Advanced Machining Processes (AMPs) are considered efficient for machining these MMCs. Spark Erosion (EDM) is one of these most popular MPAs in today's industrial paradigm for machining

these advanced materials. However, EDM also inherits limitationssuch as low material removal rate (MRR) and high tool wear rate (TWR). The powder mixed EDM process (PMEDM) can help increase the productivity of EDM in terms of MRR and TWR. In the present work the processing performance of copper-iron-graphite MMC using PMEDM was investigated. Response surface models (RSMs) for MRR and TWR have been developed. Furthermore, a hybrid approach of gray relational analysis, RSM and genetic algorithm was used for the multi- objective optimization of MRR and TWR.[8]

Soni et al. [2020] Research conducted using Response Surface Methodology (RSM) Box-Behnken (BBD) design

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with 15 main tests for three process parameters: pulse time, stopping time and electrical current. Relational Gray Analysis (GRA) and Multi-Attribute Utility Theory (MAUT) optimization techniques were used for multi-response optimization of material removal rate (MRR), electrode wear rate (EWR) and surface roughness . The best alternatives obtained using the above techniques were similar in the ranking. Confirmation tests were performed and it was observed that the difference between the predicted value and the measured value was negligible.[9]

Wang et al. [2009] presented the predictive mathematical model of surface roughness based on cutting parameters.Secondly, in this article, the cut parameter optimization model is created to achieve the maximum material removal rate and the genetic algorithm is used to find the optimal cut parameters which result in a removal rate. maximum material in the different ranges of surface roughness values.[10]

III. PROBLEM IDENTIFICATION

As from literature review it isstudied and concluded following problems that has to be tackled:

- In past research, different EDM methodologies are discussed such as wire-EDM, die sink- EDM, powder mixed EDM, dry-EDM, etc. So, there is need to explore parameter optimization and to study their effect on performance parameters under optimal EDM factors and thereby developing a mathematical model and study their combined effect for each response considering all the parameters along with the process constraintssimultaneously.

- Most of the past research work mainly used Taguchi optimization method of parameters to study their effects on the EDM process responses. More and consistent use of recent optimization techniques is also required specially to attempt multi-objective problems of EDM process.

- But in recent scenario, bio-inspired optimization techniques are used for multi-criteria decision-making such as genetic algorithm (GA), particle swarm optimization (PSO), ant colony optimization (ACO), crow optimization, etc.

IV. PROPOSED METHODOLOGY

The demand for biomedical implants is rapidly growing in order to improve the quality of human life.Such artificial components (implants) can be used for a short period of time, long-term, or even permanent in the biological tissue if not removed surgically [1]. Currently, implants are being used in many different parts of the body for various applicationssuch as orthopedics, pacemakers, cardiovascular stents, neural prosthetics, or drug delivery system [2, 3]. The biomedical components generally must have good corrosion resistance, suitable surface properties, sufficient mechanical strength, biocompatibility with tissues and bones, naturally degraded and disappeared in tissue, and also reliable chemical stability and safety [4]. In this case, metallic alloyssuch asstainlesssteel, titanium and its alloys, cobalt–chromium alloys, nickel– titanium shape memory alloys, and magnesium alloys are the most preferable biomaterials. Though ceramics and polymers can also be used as an implants. In order to alter the corrosion resistance, surface and subsurface qualities of machined magnesium alloys are normally improved using additional finishing processessuch as electrical discharge machining (EDM).

EDM is one of the advanced untraditional machining, in which workpiece material is removed through evaporation, melting and erosion. In EDM, electrode is kept at a constant gap from workpiece. The electrode and workpiece form electric circuit while electrode treated as cathode and workpiece as anode. So due to the presence of dielectric and current, potential difference between electrode and workpiece developed and spark generated. Hence due to spark erosion, conductive workpiece material of any hardness and complex shape can be machined very easily

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