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A Review on: Wire cut electrical discharge machining processfor metal matrix composite

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Abstract: An essential non-traditional machining technique called wire cut electrical discharge machining (WEDM) is utilised to produce complex forms with excellent surface roughness and precision. Numerous researchers create various models and optimise the process while taking into account a variety of process parameters and response traits. In respect to various input process parameters and several output measures, such as material removal rate, surface roughness, dimensional deviation, kerf width, and wire wear ratio, this review paper discusses the most recent research developments in WEDM. The paper examines the function of various wire materials, wire diameters, and optimization techniques in the WEDM process.

Keywords: Wire cut electrical discharge machining, Process parameters, Optimization methods

1. Introduction:

The aerospace engineering, tool, die, and mould manufacturing, metal-working, and automotive industries all use wire-EDM as a significant non-conventional machining technique. This is so that hard materials with complex shapes can be machined successfully using wire-EDM. In wire-EDM, the problem of choosing the cutting settings to achieve a higher cutting efficiency or precision has not yet been entirely resolved. A thermo-electrical method called WEDM involves repeatedly sparking the work piece and the wire electrode to degrade the material. Wire carries one side of an electrical charge while the work piece carries the other side during the procedure. When the wire approaches the component, the attraction of electrical charges causes a controlled spark that melts and vaporises minute material particles. As well, the spark removes a tiny portion of the wire, causing the machine to automatically advance new wire after the wire has passed through the work piece once. a continuously moving wire electrode with a diameter of 0.05 to 0.30 mm composed of thin copper, brass, or tungsten. This study mainly focuses on the key WEDM research activities, including the different process parameters, including wire material, wire diameter, pulse on time, pulse off time, peak current, and wire tension, wire feed rate, servo voltage, dielectric fluid, and flushing pressure.

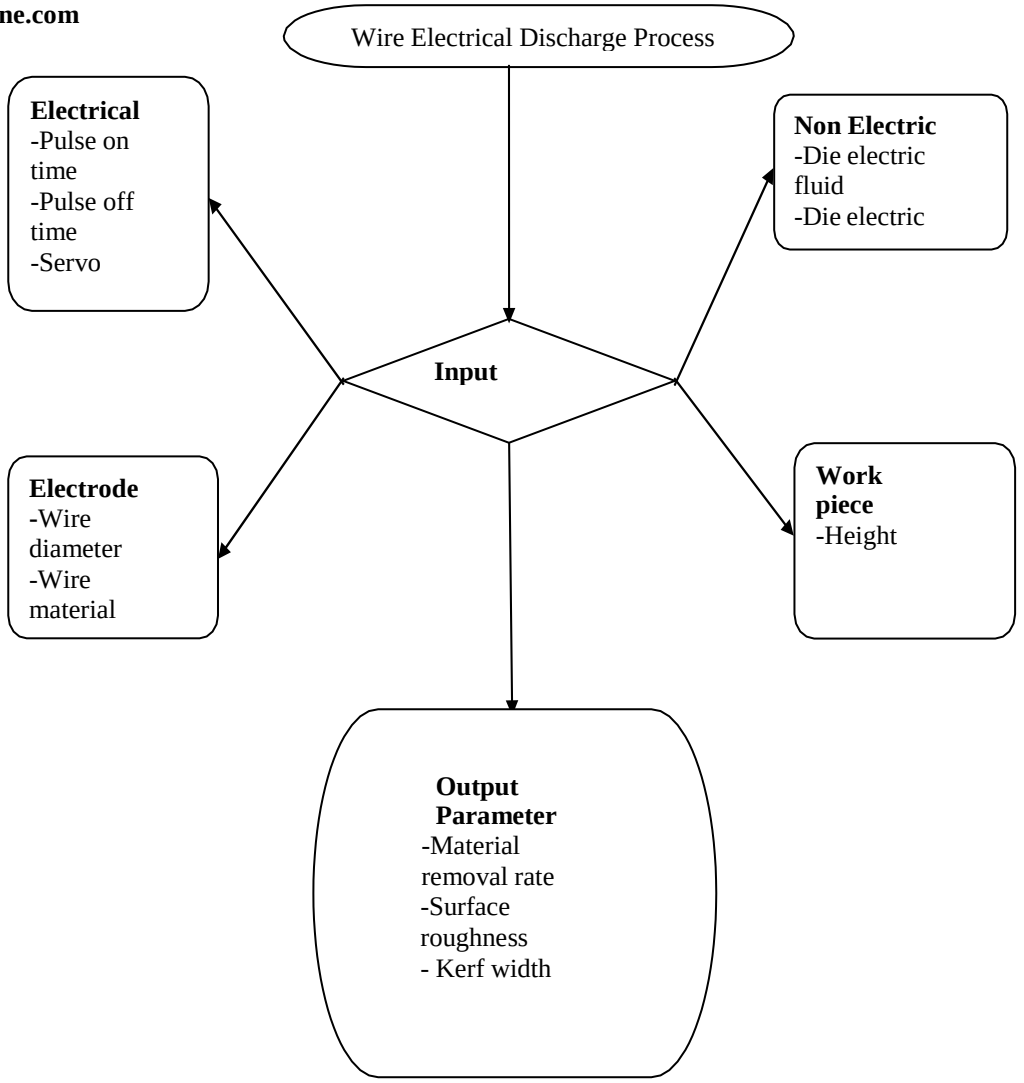

Fig. 1. WEDM process and respond parameter

2. Literature Review

Literature review section provides information about WEDM process machining parameter and its characteristics also provide information related to machining of latest composite material used in the aerospace industries,

automobile section and tooling section. Tarng and M A (1995) construct the feed forward neural network model for the wire-EDM process. A global optimization algorithm simulated annealing is then applied to this network for solving the optimal cutting parameters using an adjustable objective function.it was found that the pulse on time is the significant parameter for the surface roughness. Huang and Lio (1997) an attempt has been made on influence of the machining parameter such as pulse-on time, pulse-off time, table feed-rate, flushing pressure, distance between wire periphery and work piece surface, and machining history on the machining performance of WEDM in finish cutting operations. It compares the proposed approach with that of a well-skilled operator. It is obvious that the proposed approach can achieve a better surface quality.

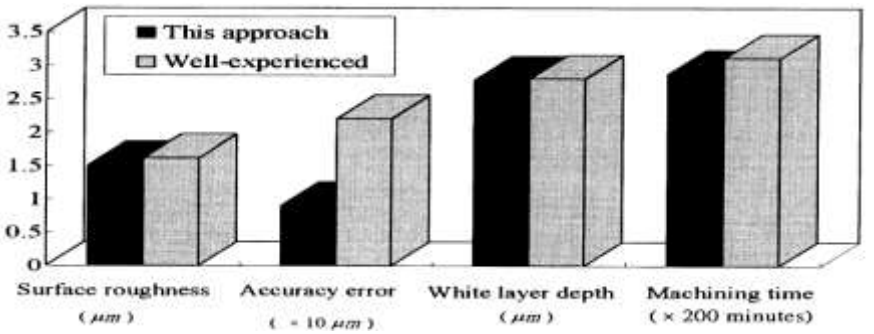

Fig. 2. Comparison of this approach with a well-skilled operation (Huang 1997)

Puri and Bhattacharyya (2003) describe average cutting speed, surface roughness; geometrical inaccuracy is mostly affected by pulse on time, pulse off time and pulse peak current during rough cutting and pulse on time and the constant cutting speed during trim cutting. Patil and Brahmankar (2010) experimental results show that increased percentage of ceramic particulates in the MMC causes decreased MRR. The decrease in MRR is almost 12% with an increase of 10% in ceramic reinforcements. Although the present models may not be suitable for different machining conditions, the methodology can be employed in the process to study the process in further details. Krishnan(2012) have conduct experiments in Wire electrical discharge turning based on Taguchi design selecting AISI D_3 Steel as work material and copper electrode as tool material. Artificial neural network with feed forward back propagation algorithm using ANFIS for modelled the WEDT Process and NSGA is use to find the optimal solution. Also it study the comparison of the all the three methods used for the prediction of surface roughness and material removal rate are shown in the following figure 3. From the figure all the three perdition models give result fairly close to each other but in the ANFIS model there were a point with lower the Ra and MRR away from the trend line and found the ANFIS model had an average error in the testing of about 27%.Chalisgaomka (2013) describes the development of multi response optimization technique using utility method to predict and select the optimal setting of machining parameters in wire electro-discharge machining (WEDM) process. Finally, confirmation experiment was performed to validate the effectiveness of the proposed optimal condition.

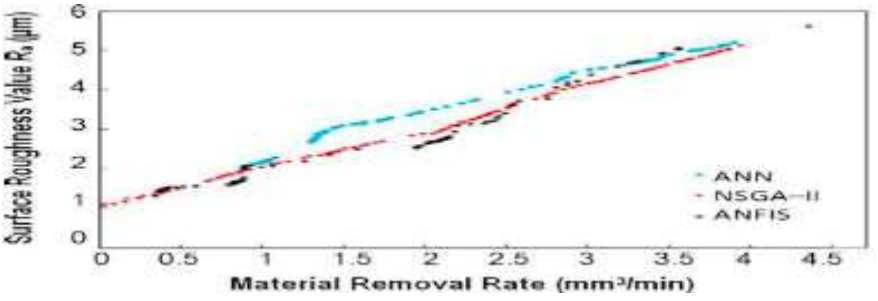

Fig. 3. Comparison of ANN, NSGA-II and ANFIS model (Krishnan ,2012)

Kannachai (2013) found that optimal cutting condition was at 2 A peak current and 772 µm off set distance. Since neither dimension nor surface roughness was affected by cutting speed, the speed was thus set at the highest of 5.5 mm/min to maximize the production rate. Rao and Krishna (2013) use combine approach of principal component analysis coupled with taguchi's robust theory for simultaneous optimization of correlated multiple responses of wire electrical discharge machining process for machining SiC_P reinforced ZC63 metal matrix composites material. Experiments were conducted by varying the particulate size, volume fraction, pulse-on time, pulse-off time and wire tension. Multi response optimization technique principal component analysis is use to derive the composite principal component which acts as the overall quality index in the process. Garg and Jain (2014) developed mathematical models to predict the results for performance characteristics well in advance. Desirability function approach is used to find the optimal parametric combination for single-objective optimization as well as for multi-objective optimization. The CV 8.1235 mm/min. and surface roughness 1.2549 µm indicate that the developed MMC can be successfully machined by wire EDM. Liao(2014) use a neural network that can accurately predict the relationship between machining parameters and characteristics for different kinds of materials through the concept of SDE is established. The neural network, employed in conjunction with the GAs optimization technique, successfully includes the variation of work piece material for the parameters setting of process planning. The system allows users to obtain the combination of machining parameters that can achieve the fastest machining speed possible while satisfying the needed machining quality with different materials. It can, thus, simplify the procedure of machining parameters setting in process planning and save a substantial amount of time and cost. Zhang (2014) proposed approach can give the optimal process parameter settings with maximum MRR and minimum 3D Sq for MS-WEDM machining SKD11 simultaneously. The confirmation experiment demonstrated that the surface quality decreases while the MRR increases with the increase of the pulse-on time. The most suitable process-parameter combination can be selected from the pareto-optimal solutions according to the requirement of manufacturing engineer. Kumar and Kumar (2015) made investigation on material removal rate and over cut in WEDM process of pure titanium using brass electrode were modeled and analyzed through response surface methodology. Dimensional analysis is used to develop the semi empirical model and developed model has been validated by comparing the predictions of the model with the experimental values of MRR and a good agreement between the two has been obtained. It was found the error between experimental and predicted values at the optimal combination level of input parameter settings for material removal rate and overcut lies within 6.95 and 6.32 %, respectively. Babu and Kiran (2016) an attempt is made to machine hypereutectic Al-Si alloys using WEDM. Pulse on time, pulse off time, wire feed rate and variation of percentage of silicon are taken as controlling factors for experimentation.Gray relational analysis and principal component analysis were used to find the optimum process parameter set. It was found that gray relational analysis is most suitable than principal component analysis. Boopathi and Sivakumar (2106) perform the experiment on oxygen-mist near-dry WEDM using taguchi's design of experiments. Regression model has been developed for material removal rate and surface roughness. Multi- objective Artificial Bee Colony (MOABC)

algorithm is used to find the optimum combination of parameter for material removal rate and surface roughness.

3. Discussion and future trends

After a thorough investigation of the published works in this field, the following conclusions can be drawn.

- The development of economical wire electrodes with high conductivity and elevated fracture toughness for high material removal rate and high cutting speed will remain a key research area.
- Very less effort has been made to identify electrode materials, keeping in view their thermal properties from the perspective of cutting speed.
- Not many studies have been conducted on the machining of ceramics like ZrO2 and Al2O3 by using assisting electrodes to facilitate sparking of these highly electrically resistive materials
- The advent of newer and more interesting materials that are productive in a wide variety of applications has challenged the feasibility of future manufacturing environments. Higher zinc content leads to faster cutting, but results are sometimes achieved only when machine settings are optimized. Optimized settings for WEDM are necessary to achieve the performance attainable with next generation wires.
- Developing wires with smaller diameters and improved wire guides for fine wires to handle small work pieces is a challenge for future manufacturers.
- Not many studied has been made effect of wire diameter and wire material on material removal rate, cutting velocity and surface roughness.
- More research and experimentation is required to enhance cutting efficiency with new combinations of core and coating materials, since existing wires do not fulfill all requirements. High-performance wire electrodes with high conductivity alloy materials for high-speed cutting applications will be extensively used for automobile parts and die manufacturing in the future.

4. Conclusion

The focus of this paper was on the evolving technologies of wire EDM wire electrodes tool from using copper to the widely utilized brass wire electrodes and from brass to the latest coated wire electrodes, which have been developed and assist user demand and needs in terms of maximum productivity and quantity. The purpose of gradually changing the zinc content in coating alloys is to provide enhanced cooling ability and flush ability compared to conventional brass wire electrodes. Alloy with higher zinc content leads to increased cutting speed and material removal rate. Also focus has been made to changing the wire diameter 0.05mm to 0.30mm increase the material removal rate and cutting velocity. The authors believe that the challenge faced by WEDM manufacturers is to continuously push the envelope in the area of developing wire EDM wire electrodes that have high conductivity, are environmental friendly, and can undergo unattended machining operations. Achieving high conductivity and strength without sacrificing fracture toughness are key research areas.

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