

# A Review on Parametric Optimization of Wire EDM of Ti6Al4V

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**ABSTRACT:** Advanced materials are being developed due to the increased improvement or enhancement in material sciences like super alloys, ceramics and composites. Materials obtained through the development of the materials sciences are hard and difficult to machine, these advanced materials also poses barrier in smooth machining process in traditional machining process such as drilling, milling, grinding and turning. To machine these advanced materials non-traditional techniques are successfully used. Among most of the nontraditional techniques Wire Electrical Discharge Machining (WEDM) is one of technique which is commonly preferred by industries for machining operations and producing the accurate and precise components. In this process very less amount of waste is produced after the machining operation. This method of machining utilizes the heat produced through the spark initialized between work piece and wire, which are immersed in dielectric solution, Dielectric solution acts as the coolant for removing or flushing the waste produced during the operation. Wire Electric Discharge Machining technique fulfills the requirement of the Industries which produces tools and machining. This technique is also an essential machining technique to produce complicated cut outs without using high cost grinders and cutting tools. Review paper highlights the work on Wire Electric Discharge Machining, that research is oriented on newer aspects of WEDM in the field of analysis and optimization, mathematical models are developed to reduce the waste of removal of material while finishing process, cutting speed and surface roughness of WEDM process have been modeled etc.

**KEYWORDS:** WEDM, Production, Technology, Machining.

## I. INTRODUCTION

Wire Electrical Discharge Machining is a form of EDM (Electrical Discharge Machining) which comes under the category of non-traditional process. This process (WEDM) is widely used in die manufacturing for die steel. Electrically conductive materials are cut with the help of electro-thermo mechanism by a series of discrete discharges between the wire electrode and work piece in the presence of dielectric fluid. An extremely high temperature occurs in the region where discharge occurs causing melting and removal of work surface. The rubble material flashes from machining zone due to the dielectric fluid. This method is widely utilized to produce components with complicated shapes and profiles. However in Wire Electric Discharge Machining (WEDM) process continuous use of the wire electrode takes place which is made of thin copper or brass, diameter of this wire ranges from 0.05-0.3mm, which has the capacity to produce a very small corner radius. To produce tension in the wire a mechanical tension device is used. Since there is no direct contact between the wire and the surface of the work piece causes elimination of stress between the wire and the work piece. This technique can be successfully utilized to cut electrically conductive materials despite its of their hardness, shape and toughness. This (WEDM) technique is utilized for the cutting and machining of high strength temperature resistant materials (HSTR) and heat treated steels.

Wire Electrical Discharge Machining: This section provides the basic principle of Wire Electric Discharge Machining (WEDM) as well as other material removal methods.

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## Basic Principle of WEDM Process:

The mechanism of removal of material in Wire Electric Discharge Machining (WEDM) is similar to conventional machining process in which erosion effect produced by the electrical sparks produced in series between the work piece and the wire electrode surrounded by stream dielectric fluid continuously flowing in the machining zone. After applying the voltage pulse between the work piece and wire electrode during the Wire Electric Discharge Machining (WEDM) process a temperature range of 8000°C–12,000°C exist between cathode and anode in the form of thermal energy takes place. The plasma channel breaks down when the pulsating DC power supply taking place between 10,000 and 30,000 Hz is turned off. As a result breaking of plasma channel a sudden reduction in the temperature allowing the circulating dielectric fluid to implore the plasma channel and flush the molten particles from the machining zone in the form of microscopic rubble.

## Mainly there are two types of Electric Discharge Machining (EDM):

Ram or die-sinking EDM and travelling-wire, wire-cut or simply wire-EDM.

The fundamental principle is similar in both. A power supply creates the voltage difference between the electrode and work piece which is electrically conductive. The electric field strength grows in the gap when tool approaches the work piece, until the electric medium separating the tool and the work piece breaks down. After the dielectric ionizes a plasma channel is created, compressing the surrounding the dielectric. The temperature and pressure of plasma may increase as high as 40,000K And pressure 3kbar. In this process heating of the work piece takes place when both electrons and ions are bombarded on the surface of work piece, heating of work piece takes place in such a manner that a part of the surface is melted. Vaporization is prevented through the plasma pressure. A vapor bubble occurs during the discharge when plasma channel is collapsed; bubble causes the superheated molten material of work piece surface to explode into dielectric. The ejected material is flushed away, portion of molten material solidify onto work piece surface which is called as the recast layer.

Wire Electric Discharge Machining decreases the requirement of elaborate pre-shaped electrodes that are commonly necessary in Electric Discharge Machining to perform both roughing and finishing operations. In WEDM a thin wire is used which continuously feeds the work piece by a microprocessor. Microprocessor helps in machining of parts into complex shapes with a high accuracy. In Wire Electric Discharge Machining (WEDM) Plasma channel exists between cathode and anode due to supplied electrical energy and finally converted into thermal energy after reaching temperature 8,000° –12,000°C and can be more as high as 20,000°C. Due to this heating and melting on the both poles surface takes place as a result. The plasma channel breaks down due to the pulsating DC power supply occurring between 20,000 to 30,000 Hz is turned off. Breaking down of plasma channel results in a sudden reduction of temperature, which flushes the molten particles from the machining zone in the form of microscopic rubbles. The gap between the wire and the work piece is also maintained by the microprocessor.

## II. RELATED WORK

1. Ms.Sharanya S. Nair, Ms.Nehal Joshi (December 2014) studied Trends in Wire Electrical Discharge Machining (WEDM)The major input parameters of WEDM are pulse on time, pulse off time, peak current, gap voltage, wire feed, wire tension etc. and the response parameters are material removal rate (MRR), surface roughness, cutting speed, surface integrity, dimensional deviation etc. In the modern era of science and technology, the requirement of accurate and precise engineering products is successfully fulfilled by the wire electrical discharge machining (WEDM) process.

2. Sivaraman B, Eswaramoorthy C, Shanmugham E.P (2015) studied the Optimal control parameters of machining in CNC Wire-Cut EDMIn this project, an application of combined Taguchi Method is to improve the multi-response characteristics of MRR (Material Removal Rate) and Surface roughness in the Wire-Cut EDM of Titanium has been reported. As a result, this method greatly simplifies the optimization of complicated multiple performance characteristics and since it does not involve complicated mathematical computations, this can be easily utilized by the stakeholders of the Manufacturing world.

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3. K. Kumara, R. RaviKumar(2013) studied the Modeling and Optimization of Wire EDM Process. In this article, an attempt was made to determine the significant machining parameters for performance measures surface roughness in the WEDM process. Factors like speed, feed, Time on and Time off have been found to play a significant role for MRR and surface roughness. Taguchi's method is used to obtain optimum parameters combination for maximization of surface roughness. The conformation experiments were conducted to evaluate the result predicted from Taguchi Optimization.

4. K. Kumara, R. Ravikumar studied the Modeling and Optimization of Wire EDM Process. As a result, this method greatly simplifies the optimization of complicated multiple performance characteristics and since it does not involve complicated mathematical computations, this can be easily utilized by the Manufacturing world.

5. C. Bhaskar Reddy, C. Eswara Reddy, D. Ramana Reddy (2012) studied the Experimental Investigation of Surface Finish and Material Removal Rate of P20 Die-Tool Steel in Wire-EDM using Multiple Regression Analysis. Numerical model is developed for predicting material removal rate and surface finish using multiple regression analysis and the both experimental and modeling results are validated and showing there is no significant change in the results at 95% confidence level.

6. Dhruv H. Gajjar and Prof. Jayesh V. Desai (2015) studied the Optimization of MRR, Surface Roughness and KERF Width in wire EDM Using Molybdenum Wire. Grey relational analysis is done to find out optimal parameter levels. After grey relational analysis, it is found that pulse on time at level 3 (130  $\mu$ s), pulse off time at level 3 (60  $\mu$ s), servo voltage at level 2 (30volts) are the best process parameter for the MRR, KERF width and Surface roughness. Process parameters do not have some little effect for every response. Significant parameters and its percentage contribution changes as per the behavior of the parameter with objective response. Increase of Pulse on time generates more spark energy as the length of time that electricity supply increases. MRR, KERF width and SR all response increasing with pulse on time. Pulse on time found most significant parameter in all response. Surface roughness also increases with increase of pulse on time because the increases of pulse on time produce crater with broader and deeper characteristic. Pulse off time has opposite effect to pulse on time.MRR decrease with increase of pulse off time, while surface roughness reduces. During off time removed material flushed away. More the off time better the flushing. Servo voltage has little effect on SR and KERF width but it has more effect over MRR. Surface roughness reduces with increase of servo voltage.

7. Tzeng and Chiu (2003) conducted experiments on castek-03 for medium carbon steel material having excellent wear resistance. The most important factors affecting the EDM process robustness were pulse on time, applied electric current in low voltage and sparking current in high voltage. The most important factors affecting the machining speed were pulse on time and applied electric current in low voltage. The gain of 13.17 dB was able to decrease the variation range to 21.84%, which improved process robustness by 4.6 times.

8. Sarkaret. al. (2005) developed a feed forward back propagation neural network to model WEDM machining process. A feed forward neural network of type 6-15-3 was adopted to model the process. Twenty-seven such optimal parametric combinations were identified out of 15625 combinations. The three most important measures of the process performance parameters are cutting speed, surface roughness and wire offset were considered. The model was capable of predicting the response parameters as a function of six different control parameters, i.e. pulse on time, pulse off time, peak current, wire tension, dielectric flow rate and servo reference voltage. It was observed that the surface quality decreased as the cutting speed increased and it varies almost linearly up to a surface roughness value of 2.44  $\mu$ m and a cutting speed of 2.65 mm/min. Beyond this value of cutting speed, surface roughness deteriorated drastically.

9. Gauri and Chakraborty (2008) suggested a modified approach of the principal component analysis (PCA) based procedure for multi-response optimization. Analysis was done data on experimental data on WEDM processes obtained by the past researchers i.e. on  $\gamma$ -titanium aluminized alloy with the settings of six controllable factors. Quality characteristics were material removal rate (MRR) (larger the better type), surface roughness (SR) (smaller the better type) and wire wear ratio (WWR) (smaller the better type).

10. Rao and Sarcar (2009) analyzed the effects of process parameters on machining characteristics for CNC WEDM for brass work pieces of varying thickness. Mathematical relations were obtained for cutting speed, spark gap and MRR.

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## III.EXPECTED OUTCOME

Major areas of Research in Wire Electric Discharge Machining:

1. WEDM Process Optimization: To obtain the optimal performance it is very important to set the various machining parameters in WEDM process.
2. Performance Measure Factors: Due to its (WEDM) complexity it is controlled by a large number of process parameters like pulse duration, discharge frequency, Discharge current etc. A little variation in these parameters can affect the performance measure.
3. Effect of process parameters on cutting rate : Various quality tools can be used to find out the factors and their inter-relationship with the other factors.
4. Effect of Process Parameters on MRR (Material Removal Rate) : Material removal rate is also a important factor can be affected by various factors.
5. Effect of Process Parameters on SR: Through influences of machining parameters on WEDM various factors can be affected.

These are the various major areas of research in Wire Electric Discharge Machining (WEDM) which are given above.

## IV. CONCLUSION

Above study clearly reflects the use of EDM process in the industry. EDM process holds an important place as a non-conventional process of machining to produce the good quality machined parts. Some more effective results can be obtained after the detailed study of this process. For the scope of work an effective study with the use of various optimization algorithms like taguchi method can be carried out to improve the machining to the greater extent.

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