Effect and Optimization of Machining Parameters on Performance Parameters of WEDM-A Review

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Abstract— Wire electrical discharge machining (WEDM) is not less than a revolutionary technology which has grown the industries to a great extent .WEDM is extended version of EDM and it was the first machine which leads the machining to the automatic processing system with sensors and software system. Machining from the conventional methods needs more human labour and wastage of productive time. WEDM was invented to ease the machining work with less human efforts and skills. Most of the research work by the researcher has been focused on effect and optimization of process parameters on performance parameters of WEDM by using different type of materials. This paper presents, the review of optimization work of process parameters (Ton, Toff, IP, WT, SV, WF, WP etc.) on MRR, SR, kerf width by using different types of machine, material and optimization techniques.

Keywords: Taguchi design approach, ANOVA, MRR, SR, Kerf width, WEDM

I. INTRODUCTION

In today's world wire electric discharge machine (WEDM) has become an important untraditional machining process for industrial purpose. It is being used in space technology, aircrafts, nuclear, armament and other production and engineering operations. Traditional methods are recognized with the direct contact between work piece and tool, tool material must be harder than the work piece material to ensure cutting. Untraditional machining is done with no direct or physical contact between tool and work piece; therefore, the frictional losses are absent in these processes. These These processes also provide high material removal rate with high surface finishing and suitable with new alloys having greater toughness, strength, hardness and impact resistance. The complex, intricate designs and geometry of work pieces can be machined with non-Conventional machining techniques such as Electrical Discharge Machining (EDM), Chemical Machining (CM), Water Jet Machining (WJM), Wire Electrical Discharge Machining (WEDM) and Electrochemical Machining (ECM) etc.The area of application of WEDM process is very wide because of its variability and excellent surface finish; it can be applied in many industries like medical, furniture, jewelry, aerospace, automotive and production industries. It can be used where operations run unattended for hours or in some cases for days.

II. WORKING PRINCIPLE OF WEDM

WEDM works on principle of spark erosion which is based on Thermo-electric theory. According to this theory, electrically conductive materials can be machine with the help of a continuous wire electrode moving throughout the workpiece. Material removal is based on melting and evaporation due to spark. Material elimination is originated by spark erosion when wire passes through the work piece over a desired path. The gap between work piece and wire electrode is supplied with continuous DC pulses. Dielectric fluid is used as a shield between work piece and wire electrode, deionized water is used as dielectric fluid. With adequate supply of voltage, the fluid ionizes and initiate spark which precisely erodes a small section of the work piece. The spark so produced melts and vaporizes the material. Electrical pulses are provided with repetitions around thousands of time per second. Dielectric fluid (deionized water) is supplied with sufficient pressure to continuously feed into process and to flush away the eroded particles. Numerical control movements ensure the accuracy and precision of WEDM in achieving required shape and size [1-5].

III. LITERATURE REVIEW

1) Carmita Camposeco-Negrete et al. (2019) performed experiments on a Sodick VZ300L CNC machine tool to get the optimized machine settings for the machining span and the surface roughness of AISI O1 tool steel under roughing conditions. Brass wire (0.25mm) is used as a tool electrode. Pulse-on time, pulse-off time, servo voltage, and wire speed are used to evaluate the results and contributions of cutting parameters. L9 orthogonal array was used to reduce the time and expense of all studies. Servo voltage is the most important factor for reducing machining time, accompanied by pulse-on time and wire velocity. The most important factor in minimizing surface roughness is pulse-off duration .Multi-objective optimization obtained by optimal approach produced to save the machining time approximately 7.50 percent and 1.16 percent in surface roughness relative to the values of the cutting parameters typically used in WEDM of AISI O1 tool steel [6].
2) Sonia Ezeddini et al. (2019) researched on based composite (Ti17) composite material in robofil 190 WEDM for the result parameter MRR and Kerf width. The brass wire of 0.25 mm diameter was selected as tool electrode. For the analysis ANOVA technique was applied and for the optimization RSM and Taguchi's approach was applied. To achieve the minimum passage of kerf and maximum MRR the mathematical models was designed with the help of ANOVA. After the analysis they observed that smaller values of kerf can be achieved by the higher values setting of servo voltage and in case of MRR the cutting speed (Cv) should be maximum. The values of predicted signal to noise ratio is very much closer to the calculated values therefore Taguchi's S/N ratio is correct so the further advanced research can be preceded. The servo voltage is most influenced parameter on the kerf values and advanced speed has the greatest influence on the MRR [7].

3) M. Subrahmanyam et al. (2019) investigated INCONEL 625 work material and used brass wire tool electrode on electronica Sprint Cut machine. MRR and SR was selected as result parameter and ANOVA technique in MINITAB 17 was applied for the optimization of MRR and Surface roughness. L 9 Taguchi's orthogonal array was applied for optimizing three different parameters so that maximum MRR and minimum SR can be obtained. The results obtained from the experiments were bent towards the process parameters Ton and Toff because of its 61.90% contribution and from the analysis after getting the results Servo voltage was marked as insignificant parameters because of its less investigation on both parameters. [8].
4) Rakesh Chaudhari et al. (2019) programmed an experiments on WEDM machine (DK7732) by using Ni55.8Ti as work material and molybdenum wire of 0.18 mm diameter. The distilled water was used as dielectric fluid. Some input parameters were selected such as (Pulse-on time, pulse-off time and peak current) on output parameters (MRR, SR, and micro-hardness (MH)).As a optimization technique response surface methodology was applied and for deep analysis heat transfer system (HTS) algorithm was used as a base model throughout the research. The approaches they used were highly advanced and capable to match the targeted results to the predicted data. After the optimization and analysis process it was observed that Toff and peak current were found to be most significant parameters those influencing SR and MH respectively. Pulse off time and current are significantly influencing MRR and regression models generated for the selected output parameters are found to be robust. [9].
5) D. Vijay Praveen et al. (2019) reviewed on the optimization techniques for the WEDM machining parameters. As work material aluminum based reinforced MMC because of its nature to withstand in high temperature zone and these are hard materials. He analyzed that it is very important to explore the various reinforcement material such as metal coated ceramic reinforced MMC, hybrid MMC at different machine settings. After the review process he objected that in maximum research papers only electrical parameters are studied but non-electrical parameters are also have equal significance [10].
6) Titus Thankachan et al. (2018) Titus Thankachan et al. (2018) provides a view on the machining characteristics of WEDM using Taguchi Method and Grey Relational Analysis based multi objective optimization. Agie Charmilles CUT 20P WEDM is used for machining of friction stir processed (FSPed) copper-BN surface composite. TON, TOFF,WF (Wire Feed rate) along with the material characteristics of varying Boron Nitride (BN) volume are processing parameters and Material Removal Rate and Surface roughness are output responses which are obtained with the help of L27 orthogonal array. It is found that TON and BN volume fraction is most significant for MRR, while surface roghness influences most by TON and TOFF. Based on experimental values for MRR and Ra, a mathematical model is developed using the control factors [11].
7) Alaa M. Ubaid et al. (2018) presentsoptimization of the EDM process for machining SS304 (ASTM A240) on CHEMER EDM machine type (CM 323C) and Current, Pulse on Time, Pulse off Time are taken as process parameters. Material removal rate (MRR), and electrode wear ratio (EWR) are used as performance measures. Signal to noise ratio calculated for each one of the performance measures, and Multi Response Performance Index generated using Fuzzy Logic Inference System. Optimal setting for process parameters for machining SS304 is; Current 10, Pulse on Time 60 µs, Pulse off Time 35 µs. ANOVA gives the result that Pulse off Time, and Current are the significant process parameters affecting the performance measures and the Pulse off Time is the most significant parameter [12].
8) Nitesh Kumar et al. (2018) investigated the effect of input parameters on output parameters of WEDM. For this investigation they used, MRR and SR as an output parameter, Ton, Toff, WT, Sv as input parameters, tool steel A2 as workpiece material and coated brass wire as cutting tool on Electronica Ecocut WEDM. After analysis of experimental result by Taguchi approach and ANOVA, it is found that WT, Ton is the most significant and Toff, SV is less significant factor on MRR and WT, Sv is the most significant, Ton, toff is less significant factor on SR [13]
9) Kuldeep Singh et al. (2018) presents a study on variation of cutting performance of process parameters pulse on time, pulse off time, wire type, and peak current on Electronica Sprint cut CNC WEDM. Soft brass wire and zinc coated diffused wire of dia 0.25 mm is used as tool electrode and die tool steel H-13 (155 mm× 70 mm×14 mm) work material. Taguchi method is used for designing the experiments and optimal combination of WEDM parameters to achieve better surface finish and material removal rate. It is concluded that input parameters pulse on time and pulse off time are significant factors for material removal rate and pulse on time is the most significant factor for surface roughness [14].
10) Sunil Kumar et Al. (2018) investigated the effect of process parameters on output parameters of WEDM. For this investigation they used, MRR and SR as an output parameter, Ton, Toff, Ip, Sv as input parameters, hot work tool steel H21 as workpiece material and coated brass wire as cutting tool (0.25 mm) on Electronica Ecocut ELPULS-15 WEDM. After analysis of experimental result by Taguchi approach and ANOVA, MRR is mostly affected by Ton, Toff, and IP. The third level of Ton has more effect on MRR. SR values are influenced mostly by IP, Ton and Toff. The first level of Toff has more effected on SR [15].
11) N.E. Arun Kumar et al. (2018) by using optimization techniques RSM and ANOVA to formulate experiments and optimize the responses of near-dry WEDM process for machining Monel 400 (Nickel and copper alloy) of 5mm thickness. Brass wire of 0.2mm diameter is used as tool on CONCORD WEDM DK7725 machine. It is concluded on the basis of Response surface methodology and developed mathematical models that TON, TOFF

and Voltage are the significant input parameters for MRR and SF. High MRR and SF are attained using Air-water mist at inlet pressure of 3bar [16].

12) Md Eshan Asgar et al. (2018) reviews the current research trends in WEDM and suggests the suitable input parameters and their effects on performance parameters under normal or cryogenic treated tool electrode conditions. It is observed that on increasing servo voltage and pulse-off-time surface finish increases. MRR and SR are not majorly affected by wire feed & wire tension. Also, it is observed that wire breakage is a major problem causes limitations on cutting speed [17].
13) Kashif Ishfaq et al. (2018) uses WEDM process to generate a high-speed steel form tool. Input parameters taken are Pulse on-time, pulse off-time, servo voltage, wire tension, flushing pressure whereas response parameters are tool geometry (clearance angle, included angle), SR and MRR. Experiments are performed on CNC WEDM G43S using brass wire of diameter 0.25 mm of tensile strength of 800–1000 MPa. Distilled water along with sodi¬um zeolite is used as dielectric. RSM is used for design of experiments and ANOVA shows that pulse on-time and pulse off-time are most significant input factors for MRR, SR, clearance angle and included angle. To find out the optimal ranges of the most significant input parameters for response parameters Contour plot analysis has performed [18].
14) R. Arunbharathi et al. (2017) presents optimization of process parameters of WEDM process on machining AISI H13 die steel. Five axis Electronica Sprintcut 734 CNC wire cut machine is used for machining with the help of a brass wire of 250µm diameter. Pulse on time, peak current, pulse off time and wire tension are taken as input parameters to get the desired results such as maximized MRR, better surface finish and reduced kerf width. 30 experiments are performed based on the full factorial central composite design using RSM and performance characteristics MRR, SR and Kerf Width are analyzed using Minitab software. MRR increases with an increase of pulse on time and decreases with increase in pulse off time. WT has no significant effect on MRR. For kerf width, all parameters found to be significant and Surface roughness value increases with increase in pulse on time and peak current and decreases slowly with increase in pulse off time [19].
15) Somvir Singh Nain et al. (2017) studied the behavior of Udimet-L605 on WEDM. Experiments are performed on the Electronica sprintcut (Electra-Elplus 40A DLX) CNC and plane brass wire of dia 0.25 mm is employed in experiments. Taguchi orthogonal L27 array is used in this study, considering six input variables. SEM and EDX analysis is used to examine micro structural and compositional changes of work piece. It is concluded that pulse-on time, interaction between pulse-on time & pulse-off time, spark-gap voltage and wire tension are significant parameters for surface roughness while pulse-on time, spark-gap voltage and pulse-off time are the significant parameters for material removal rate. The thickness of the white layer and the recast layer formation increases with increases in the pulse-on time duration [20].
16) Vikram Singh et al. (2017) investigated the effects of process parameters on performance parameters using WEDM machine (Electronica Ultracut S2) at Electronica Machine Tools Ltd. AISI D2 steel has been cut using brass wire of diameter of 0.25 mm. Pulse on time, pulse off time, peak current, servo voltage, and wire feed are taken as process parameters while MRR, SR, gap voltage, gap current, and cutting rate are performance parameters. RSM and Taguchi's orthogonal array L27 (35) is used to design the number of experiments and ANOVA has been used to analyze the results. Most significant factors that affect the gap current, cutting rate and MRR are pulse on time, pulse off time, and servo voltage. Factors affecting SR are pulse on time and servo voltage [21].
17) Ibrahem Maher et al. (2017) make efforts to minimize wire rupture on WEDM using Taguchi technique. Computer numerical control WEDM machine tool is used to cut Titanium alloy (Ti6Al4V) work piece with the help of a coated brass wire (coated with a high zinc concentration layer). L18 orthogonal array is used to execute experiments and each are repeated three times to ensure accuracy in taking readings of the wire rupture. The effects of peak current, pulse width, charging time, wire speed, and wire tension are studied with statistical methods of signal to noise ratio (S/N ratio) on wire rupture. It is concluded that peak current, pulse width, and wire tension are most significant factors affecting wire rupture followed by charging time and wire speed [22].
18) BijayaBijeta Nayak et al. (2016) experimentally investigated and optimize various process parameters of WEDM process during taper cutting of deep cryo-treated Inconel 718. Agie-Charmilles Technologies Corporation manufactured AC Progress V2 high precision CNC WEDM is used to perform experiments. Inconel 718 of diameter 25 mm is cut by using cryotreated coated Bronco cut-W wire electrode of dia. 0.2 mm. ANN (artificial neural network) model helps to determine the relationship between input parameters and performance characteristics. A new meta-heuristic approach known as bat algorithm is obtained through optimization of model. It is revealed in this study that during taper cutting in WEDM process the proposed method is an effective tool for optimization of performance characteristics [23].
19) Mayur N. Patel et al. (2016) optimize MRR and SR on WEDM for Tool Steel EN-31 work piece by using Taguchi Approach. ECOCUT WEDM machine from Electronica India Pvt Ltd is used to perform experiments. Brass wire of 0.25 mm diameter is used to cut 31.4 mm thick rectangular shaped EN-31 which have 1.07% Carbon. Deionized water is used as dielectric medium. Pulse duration on and off time (TON and TOFF), Cutting speed (CV) and Peak Current (IP) are chosen as input process parameters and MRR and SR as response parameters. Results from ANOVA shows that Cutting speed, pulse off time and peak current are most significant parameters to obtain higher value for MRR wheras pulse on time is least significant. For SR Cutting speed, Pulse on time and pulse off time are most

significant parameters to obtain minimum value and Peak current is least significant [24].

20) U. A. Dabade et al. (2016) analyzed the WEDM process for MRR, SR, dimensional deviation and kerf width during cutting of Inconel 718 by using Design of Experiments (Taguchi methodology, L8 Orthogonal Array). The experiments are performed on ELEKTRA SPRINTCUT WEDM machine using Zinc coated brass wire of dia. 0.25 mm is used as a tool electrode to cut Inconel 718. Minitab 16 software is used for analysis and it is concluded that pulse-on-time influences the most all the variables at 95 % confidence level and its contribution is 54.32 %, 58.42 %, 83.21 % and 36.11 %. For MRR and SR servo voltage is next significant parameter [25].
21) Rupesh Chalisgaonkar et al. (2016) investigated effects of process parameters on performance characteristics cutting speed, surface roughness and the surface integrity after finish cut. Pulse on time TON, TOFF, IP, WF, SV, wire offset (WOFF) and wire type (zinc coated and uncoated brass wire) are taken as process parameters. In this study commercially pure titanium is cut on Sprintcut (ELPULS-40A DLX) CNC WEDM machine using zinc coated and uncoated brass wire of dia 0.25 mm. ANOVA gives that type of wire material, TON and wire offset are most influencing parameters for cutting speed and surface roughness, and lower values of pulse energy parameters and WOFF, with uncoated brass wire as a tool gives improved surface finish during trim cut process. Fuzzy logic methodology is used to find out the optimal parametric combination for responses characteristics with the help of MATLAB7.8.0 and Minitab 15 software [26].
22) Vipul Kumar et al. (2016) studied about the research work expressed in the different fields of WEDM such as in modelling and simulation, optimization, ultrasonic vibrations, dry machining, composite materials and other key studies comprising effects, investigations, improvements and developments employed in the field of WEDM. It was concluded that the wire should have sufficient tensile strength and fracture toughness, as well as high electrical conductivity to remove unwanted material from work piece. It was also determined through the experiments that high TON time, low TOFF time and low SV produce optimal value of cutting rate, surface roughness was affected by pulse on time and ultrasonic vibrations. It was found that Wet WEDM provides better surface texture as compared to Dry WEDM. Here MRR get reduced on increasing TOFF time, IP and SV [27].
23) Naveen Kumar et al. (2015) in his review article, it is suggested the future researches along with the study of WEDM. This emphasize the work done in the area of WEDM associated with several parameters such as TOFF, TON time, IP, WF rate, SV, and their respected effects on output parameters like MRR, surface integrity, wire lag and inaccuracy [28].
24) Rajan Jindal et al. (2015) investigated by applying RSM design technique on work material AISI H21 & CNMG 120412 MP of Grade TT 8135 steel. They used 0.25 mm brass wire as tool electrode. Output parameters for the analysis are SR & MRR. Whole experiment was done by installing our work piece on CNC STALLION-100 HS. The experimental results obtained from the experiment were quit interesting because the values of MRR were increased with the increase in feed rate, spindle speed and depth of cut. Surface roughness decreased with the increment in spindle speed but increases with increase in feed rate [29].
25) B Sivaraman et al. (2015) investigated on WEDM machine by taking Titanium as work material and brass wire of diameter 25 mm as tool electrode. The input process parameters were selected includes dielectric pressure, Pulse ON, pulse off , Wire tension, Wire feed rate, Gap voltage, and Average gap current and the output parameters selected SR, Electrode wear, MRR . For the optimization of the process Taguchi approach of orthogonal array 9 was applied. After analyzing the process it was concluded that taguchi's design approach is best methodology [30].
26) Vivek Aggarwal et al. (2015) studied the effect of WEDM process parameters (Ton, Toff, Ip, SV, WF and WT) on MRR and SR by using RSM. WEDM machine Elektra Sprintcut 734 is used to perform experimental work on Inconel 718 by using 0.25 diametric zinc-coated brass wire as tool electrode. After analyzed of experimental result, it was found that Ton to be the most influencing factor for MRR and SR. WF and WT are found to be most insignificant factors on the performance parameters [31].
27) Anurag Joshi et al. (2014) studied on the different control process parameters of WEDM to elaborate process limitations for tool and die steel. For experimental work, they used tool steel grade EN 31 as a workpiece material and 0.18 diametric brass wire as tool on Electronica DL-25 (4-axis) CNC Wire EDM.Input process parameters of WEDM are bed speed,IP, TOFF time and TON time. Experiments results were analysed through Taguchi Technique in statically analytical software (Mintab). After analysed the experimental result they found that, MRR shows increment with the increase in TON time and bed speed and MRR shows decrement with low TOFF time [32].
28) P Abinesh et al. (2014) studied the parametric effect of WEDM on MRR, SR and EWR by using Taguchi design methodology. L16 orthogonal array was select to perform experiment on Electra Sprintcut-734 CNC machine by using Titanium alloy (grade 5 & 2) as workpiece material and brass, Nickel coated brass wire (0.25 mm dia.) as tool electrode. Five input parameters were selected for experiment work are Ton, Toff, Ip, wire material and workpiece material with two level. After analysis of experimental results, it was found that MRR increase with increase in Ton, Toff but EWR decrease with increase in Toff, Ip. However, SR increased with increase in the level Toff, Ip and decreased with increase in the level Ton [33].
29) Noor Zaman Khan et al. (2014) studied the High Strength Low Alloy Steel ASTM A572-grade 50 on Steer Corporation DK7712 NC WEDM machine by taking SR average and micro hardness as process parameter. For the optimization both Taguchi's orthogonal array and GRA method were applied and the workpiece was gone

through total number of nine experiments. After the optimization of the process it was observed that the pulse OFF time was most significant factor for the SR as well as for the micro-hardness of the workpiece. Also it was calculated that when we increased the TON time the values of SR and the micro-hardness was also increased. The values of surface roughness settings were also increasing when we increase the IP [34].

30) Pujari Srinivasa Rao et al. (2014) investigated on Aluminium BIS-24345 alloy in WEDM. For this investigation they took TON, TOFF, IP, WF, WT, SV SF and flushing pressure of dielectric as input parameters and MRR as output parameter. For the optimization of the results Taguchi design L18 orthogonal array approached was applied at Different levels of input parameters. The analysis table of experiments were made through ANNOVA. Throughout the process it was analysed that IP was for the most part substantial parameter than the others. The WF and WT are the less significant parameters [35].
31) Amitesh Goswami et al. (2014) investigated on Nimonic 80A and he experimented on ELECTRONICA SPRINTCUT (Electra-Elplus 40A DLX) CNC WEDM by taking surface integrity of the work piece as the base of the experiment. Output process parameters selected were material removal rate (MRR) and wire wear ratio. Taguchi's design approach was used for the DOE. There was total number of ten Input process parameters were selected peak current, pulse ON time, pulse OFF time, wire speed, wire tension, wire offset, spark gap and pulse peak voltage, servo voltage, flushing pressure respectively. After the machining process for the deep study of surface of the work material at microscopic level the Scanned Electron Microscopy (SEM) was performed. At the end of the observation process it was concluded that thick recast layer results were approached through the higher value setting of pulse ON time. When the settings of the machine were lower for the pulse ON time and higher for the pulse OFF time the wire deposition on machined surface was lower [36].
32) Gaurav Sachdeva et al. (2013) researched on WEDM by taking the H-21 die tool steel as work piece and taguchi's Technique with L18 orthogonal array technique was used as Design of experiment. Zinc coated brass wire was used as tool electrode. There was total number of five input parameters (TON time, TOFF time, CS, wire speed and WT) and SR was selected as result parameter. For the analysis ANOVA was used. It was concluded from experiments that for continuous quality enhancement and higher machining efficiency Taguchi's technique is major method to predict optimal parameter values [37].
33) Prajapati S. et al. investigated on Electra Sprintcut CNC WEDM and used AISI A2 tool steel as a work material. TON, TOFF, SV, WT, WF were selected as process parameter and MRR, kerf width and SR as result parameters. Taguchi L27orthogonal array was elected for the design of the experiment. After analysing all the results, they concluded that TON and TOFF are the most valuable process parameter for MRR and SR. SV is most prominent for kerf width [38].
34) M Durairaj et al. (2013) researched on Wire EDM for the work material SS304. He used distilled water as dielectric medium and a brass wire of 0.25 mm diameter as tool electrode. For the design of experiment he applied two approaches Taguchi's L16, orthogonal array technique and Grey relational theory for the optimization process. The experiment was scheduled for optimise to minimum kerf width and the best surface finishing of the work material. There were two categories selected for input parameters first was fixed parameter (WT, Dielectric fluid pressure, wire speed, resistance and cutting length were categorised as fixed parameters) and other was variable parameters (TON, TOFF, WF, SV) for measuring the SR the surf coder instrument was used and for measurement of kerf width VMS (video measuring system) technique was applied. For the optimisation process the mathematical models were prepared by Multi objective optimization technique and GRA technique and to determine kerf width in deep. Taguchi optimization technique was very helpfull for design of experiments and optimization of parameters [39].
35) Pardeep Gupta et al. (2012) experimented on HSLA work material in WEDM. Experiment was preceded for kerf width (output parameter) with respect to TON time, TOFF time, SV, WT and IP as input parameters. The RSM was applied as Design of experiments. It was concluded that kerf width decreases when we continuously increase the TON time, TOFF time, SV and IP and on the other hand Kerf width increases when we increase the WT setting. After the proper analysis of the obtained results it was concluded that SV, TON, IP and TOFF are the most significant factors for the output parameter kerf width [40].
36) Rajeev Kumar et al. (2012) researched on work material AISID2 and SUS 304 stainless tool steel and introduced some new factors during the analysis and optimization process in WEDM machine. The analysis process for the output parameter (Material removal rate and Surface finish) was preceded with the help of some mathematical models at different machine settings. While for the analysis neural network model and simulated annealing algorithm techniques were followed. The response surface methodology and ANNs were used in modelling for cutting speed and surface roughness in WEDM. After the analysis it was concluded that the results observed by the mathematical models are far better than the other techniques of DOE [41].
37) J R Mevada et al. (2012) investigated on WEDM machine by taking wire wear rate (WWR) as output parameter and IP, TON and TOFF time as input parameter. Factorial approach was used as design of experiment. For experiments on WEDM, EN-8 used as workpiece and 0.18 diametric molybdenum wire was selected as tool electrode. For the analysis purpose ANNOVA was applied. It was observed that IP and TON time were most significant factors for WWR because if we increases with increase IP and TON time the WWR also increase. Also, it was found that WWR was not much affected with TOFF time [42].

38) D Satish Kumar et al. (2011) experimented on work material (Al6063/Sicp composite) and experiment was conducted on WEDM. He took SR as output parameter. There were total four input parameters were selected such as Pulse on time, Pulse off time, gap voltage, wire feed. Sicp composite was mixed in different proportions of alluminium i.e 5%, 10% & 15% by stir casting method and then machining process of pure Al 6063 and Al MMC was done. After theanalysis it was concluded that when we increase the proportions of of Sic particles in MMC the SR was also increased. Relative significance of all the input parameter was observed [43].
39) V. Muthu Kumar et al.(2010) Experimented on WEDM machine by taking Incoloy 800 super alloy as work material for the optimization of performance parameters MRR, SR and Kerf width. They applied Grey–Taguchi Method as design of experiments. SV, TON, TOFF and WF were selected as process parameters. Taguchi's L9 Orthogonal Array was used for conducting the experiments. GRA method was applied for the optimization purpose. Analysis of Variance ANOVA was used for the analysis. Non-linear regression methodology for the design of experiments was applied and its significance was judged by the data results. After the analysis process it was observed that the predicted values were matching with obtained data [44].

IV. CONCLUSION

From the above literature survey of various researcher, it is concluded that Wire Electric Discharge Machine is the better unconventional machining process of machining of different complex shape and size (2D or 3D) workpiece having high hardness and strength with high MRR and better surface finishing. The effect of different input parameters on output parameters and effective optimization technique are discuss below:

1) TON, TOFF, IP, SV, WT, WP are the highly and SF, WF are the less influence parameters on MRR and SR.
2) TON, IP, SV, WP are the most significant factors for kerf width and tool wear.
3) Taguchi design methodology and ANOVA are the decent technique for design of experiments and optimization of wire EDM input parameters.

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