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Application of Taguchi Method to CNC Wire Cut Machine for Quality Improvement- A Review

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*Abstract***:** *CNC wire cut machine is one of the trending non-traditional machining process. CNC wire cut machine is used when higher accuracy is needed for work. CNC wire cut machine is able to cut upto 45-degree incline surface accurately so it's a very important task to study about it. In this research paper the review of CNC wire cut machine outcome parameter optimization for better result is done. Also tries to find significant best parameters for machining and the material on which the study had been done and yet to be done.*
Keywords: CNC wire cut machine, Taguchi method, Parameters

I. INTRODUCTION

CNC wire-cut machining is the latest non-conventional machining process which is based on thermo-electric energy between wire and work piece for cutting conductive materials. The mechanism of material removal in this machine is based on the melting and vaporization of work piece material. The applied potential difference creates a channel of plasma between wire and work piece. The wire is immersed in dielectric fluid[1]. Very small gap takes place between work piece and wire where discharge takes place because of high flow of current. The area where discharge takes place is heated extremely at high temperature so that localize melting and evaporation of work piece surface occurs. CNC wire-cut machine is modification of EDM and it is commonly known as Wire electro discharge machine or Wire cut Electro Discharge Machine. Using this machining process up to 300mm plates can also be cut which is difficult in any another machining processes. The guides of CNC-wire cut machine is usually CNC-controlled,(so this is known as CNC Wire cut machine). The upper spool end guide can move in z-u-v axis so that it allows us to cut up to 45 degree tapered. In CNC wire-cut machine de-water is generally used as a dielectric fluid. Filtration unit and de-ionizing units are also there to control resistivity and other electrical properties. The flushing helps to determine the feed rates. CNC-wire EDM is used in field of Mould making, nuclear power station equipment, semiconductor applications, Medical, automobile industries, for cutting hard extrusion dies, making of cams, fixtures and cams, cutting of gears, punches, stippers, manufacturing of hard electrodes. The process parameters for this machining process are Pulse on Time, Pulse off Time, Corner servo, Flushing pressure, Peak current, Wire feed, Wire tension, Spark gap set voltage and Servo feed.[2]

Taguchi is statistical method for quality improvement, Taguchi and Konishi a Japanese scientist have developed this method [3]. Initially it was developed to improve Improving the quality of manufactured goods but then after it is used in many field in engineering [4]. First Taguchi method targets to develop the design for studying variation, after getting positive result the selection of process parameters is the thing. The process parameters then grouped in two manner one is control factor another is noise (non-control) factor. This method involves to identify proper factors to obtain optimum result. Set of experiment is conducted using Orthogonal Arrays [5].

II. LITERATURE REVIEW

Rajesh and Sethuramalingam (2017) have researched to find the optimal setting of the process parameters on the Wire cut electro-discharge machining for Stainless Steel 316 grade material had been obtained using Taguchi method by considering the constraints. The process parameters chosen for this research are pulse on time, pulse off time, servo voltage and wire feed rate. These chosen process parameters used to control non controllable parameters such as Material Removal Rate (MRR) and surface roughness (Ra). The optimum values for setting of that parameters they found are pulse on time 5 µs, pulse off time 8 µs, gap voltage 60 V, wire feed rate 8 mm per min.[6]. U. A. Dabade et al. (2017) have taken work piece material as aluminum metal matrix composite ie (Al5052, Al6082, Al7075). The input parameters were Pulse on Time, Pulse off Time, Wire feed rate, Flush rate, servo feed.[7]

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S. S. Karidkar(2016) have worked for material Inconel 718 using taguchi technique. In their work they were trying to achieve the best combination of controllable parameters, there they take pulse on time, pulse off time, Peak current, wire feed, wire tension and spark gap set voltage which gives best result for the response variables. The response variables they takes are Material Removal Rate, Surface roughness, Cutting width, Dimensional deviation. They also finds the most significant factor which is pulse on time[7]. B. Prasad and G. Vinod Reddy(2016) have worked for SKD alloy steel and the control factors taken were pulse on time, pulse off time, table feed, wire tension, wire speed, flushing pressure and the performance measured for gap width, metal removal rate, surface roughness, discharge frequency, gap voltage, normal discharge frequency ratio. They also found from the experiment that pulse on time has the significant most effect for best output[8]. Manikandan et al.(2016) have selected EN-31 as a work piece material. The pulse on time, pulse off time and wire tension were taken as a controllable factor. They were trying to achieve best result for Material removal rate, Kerf width, and surface roughness[9].Mohd Atif et al.(2016) also have worked for EN-31 tool steel, He had taken pulse on time, pulse off time and peak current as a input parameters. They found that most significant factors were pulse on time and peak current[10]. Smita and Minakshi(2016) have reviewed different literature and states that main factors for input taken were pulse on time, pulse off time and peak current and also states that the material which is very difficult to machine via traditional method can successfully and efficiently machined by CNC wire cut machine[11]. Sachin Ajay and Shravan(2016) have taken WC-CO composite for their experimental work and choose taguchi based L27 Orthogonal array. The input parameters taken as work piece thickness, peak current, pulse on time, pulse off time, and wire feed rate. They also found Pulse on time as a most significant factor with 95% confidence level[12]. Ayan et al.(2016) Have taken boron carbide as a work piece material for measuring output as machining speed and surface roughness. The input factors are Pulse on Time, Pulse off Time, peak current, Servo feed, Water pressure. They observed that peak current and pulse on time have significant effect on surface roughness and Pulse on time, water pressure and servo feed have the significant effect on machining speed[13]. Rajeev Kumar (2016) have taken AISI D3 as a work piece material and peak current as a input parameter. He found that with increasing peak current cutting speed increases. Surface roughness also increase with increasing peak current[14]. Rajyalakshmi(2016) worked for optimum value for material removal rate and surface roughness for that she takes monel 400 super alloy as a work piece material. The input parameters she has selected were pulse on time, pulse off time, peak current, wire feed also found that pulse off time and peak current have significant effect on process[15]. Anup kumar et al.(2016) have worked for aluminum HE15WP material using grey relation analysis. The selected Input parameters are Pulse on time, Pulse off time, servo voltage and wire tension. The performance measured for material removal rate, surface roughness and hardness[16]. N. Jamuna and Sreenivasulu(2016) have taken input parameters as servo feed, wire feed, pulse on time and pulse off time and work piece materials as aluminum matrix composite. For obtaining responses such as kerf width, tool wear, process cost and surface roughness[17].

Ugrasen et al.(2015) have selected HCHCr as a work piece material and input parameters were Pulse on Time, Pulse off Time, peak current, Bed speed. They concluded that the pulse on time is the most significant parameters[18]. Nishant and Virender (2015) have worked for Sub zero treated SKD11 material. Input parameters were Pulse on Time ,Pulse off Time ,Wire Feed ,Servo voltage and response parameter is kerf width[19].Ibrahem et al.(2015) have selected the work material as AISI1050 carbon steel. The input parameters selected for experiment were Pulse on time, Wire tension, Peak current where he found that peak current and pulse on time were the most significant parameters[20]. Chengal, Deepthi and Jayakrishna (2015) worked for aluminium HE30 material as a work piece. The input parameters they have selected were Pulse on Time, Pulse off Time, peak current, Wire tension, Upper flush, Lower flush. To achieve material removal rate and surface finish were the key aim of them, they also suggest that lower flush and upper flush is also essential for achieving higher quality machining[21]. Chinnadurai and Vendan(2015) have selected AISI4140 as a material for experiment and the input parameters were Pulse on Time, Pulse off Time, peak current, Wire Feed, Wire tension, servo voltage, Servo feed setting also they used two type of wire for different set of experiment one is zinc coated another is uncoated. They also found that peak current and pulse on time have larger effect on MRR using brass wire, While using zinc coated wire; pulse on time, pulse off time and servo voltage are the most affecting parameters for aching higher material removal rate[22]. Ravindrananadh, Madhu and Gogia have worked for ballistic grade aluminum alloy material and chosen the input parameters Pulse on Time, Pulse off Time, peak current, Servo voltage for performance measuring of material removal rate, surface roughness, and gap current. They confirmed that pulse on time, Pulse off Time, and peak current were the significant variables[23]. Manjaiah et al.(2015) had selected Ti50Ni50-xCux shape memory alloy as a work piece and the input parameters were Pulse on Time, Pulse off Time, Servo voltage, Wire speed, Servo feed. He found that servo voltage, pulse on time and pulse of time have most significant effect on material removal rate and surface roughness in both he case while using brass wire and zinc coated brass wire. They also found from the experiment that zinc coated brass wire is not suitable for matching particular material but brass wire is the best for

the same[24].Prasenjit, Bikas and Payal(2015) have had pulse on Time, pulse off Time, peak current for the Inconel 800 work piece material. In addition they also checked the overall performance for the same and find that pulse on time gives highest contribution[25]. Abhishek and Behl(2015) tried to identify the effects of different process parameters of CNC wire cut machine such as pulse on, pulse off, Servo voltage and wire feed for analysis the material removal rate for the machining of AL6063-T6 material. They found from experiment that for material removal rate pulse on time, pulse off time and Servo voltage are the significant best process parameters[26]. Vates, Singh and Tripathi(2015) have choosen AISI D2 tool steel material for experiment and as an input parameters they selected Pulse on Time, Pulse off Time, Wire tension, Wire feed rate, Flush rate, Gap Voltage and as a response variable material removal rate and surface roughness had taken. Also states that pulse on tie and spark gap voltage are most significant parameters[27]. Manoj (2015) had selected pulse on time, pulse off, servo voltage as an input parameters to achieve best Material removal rate for machining D2 tool steel [28].

Amitesh and Jitender (2014) have worked for nimonic-80A material and the outcome parameters were selected as material removal rate and surface roughness with surface topography. For the machining, input parameters selected were pulse on Time, pulse off time, peak current, wire Feed, Wire tension, spark gap set voltage. Also concluded that material removal rate increases with increasing pulse on time and pulse on time had more impact towards achieving best outcome[29]. Sudhakaran and Prashanthi (2014) had taken tool steel(vanadis-4e) as a workpiece material and as a input parameters pulse on time, pulse off time, peak current, wire tension, spark gap set voltage, water pressure. Also found that pulse on time and peak current had large impact on outcome[30]. Nishant and Virendra (2014) had selected sub-zero Treated SKD 11 as a material as they selected before (Nishant and Virendera 2015) but this time they choose different input parameters ie. pulse on time, pulse off time, servo voltage, wire feed[31]. Rupesh and Jatinder (2014) have taken commercially pure titanium for experiment and the input parameters selected for machining were pulse on time, pulse off time , peak current, wire feed, servo voltage, wire offset. There were two types of wires had selected for their experiment uncoated and zinc coated[32].Manjaiah, Narendranath, Basavarajappa (2014) have done experiment to optimize the material removal rate and surface roughness for the TiNi shape memory alloy. The input parameters he had taken as a servo voltage, wire speed, pulse on time, pulse off time, flushing pressure. Also find that Pulse on time is the most significant parameter for this experiment[33].

Rajyalakshmi and Venkata (2013) have worked for inconel 825 work material and for machining, input parameters taken as pulse on time, pulse off time, wire tension, wire feed rate, flush rate, gap voltage, servo feed, corner servo. The output parameters were Material removal rate, surface roughness and kerf width. Also finds that pulse on time and servo feed is most important things for achieving optimum value[34]. Alpesh and Vishal (2013) had taken wire feed, wire tension, discharge current and discharge voltage as a input parameters for the Aluminium alloy A1050A work material. Their aim was to find optimum output so that overall productivity get improved. The output parameters selected for that were material removal rate and electrode wear rate[35].

Brij et al. (2012) have taken AISI316L as a experiment material and the input parameters for machining were pulse on time, pulse off time, peak current, servo voltage. They analyzed that pulse on time is most significant parameter for surface roughness[36].Dharmender, Rajeev and Anmol (2012) have taken EN31 tool steel for work material and input parameters were pulse on time, pulse off time, peak current, wire tension. After experiment they find that the pulse on time and pulse off time have larger effect on surface roughness[37]. Esme, Sagbas, Kahraman (2009) worked for AISI4043 steel and the input parameters taken as pulse on time, wire speed, flushing pressure for the material. They also find that while increasing pulse on time, open circuit voltage and wire speed leads to increase the surface roughness, whereas increasing the flushing pressure leads to decrease the surface roughness[38].

III. CONCLUSIONS

From the above literature review the conclusion drawn that Taguchi method is best method for parameter design because it leads to less experiment compared to full factorial design. Also, this method is simple and very efficient. The material which is very difficult to machine while using conventional machining process can be machined using CNC wire cut machine. The most significant parameters for machining depends upon many factors like material, wire material and all but mostly find parameters were pulse on time, Peak current and pulse off time. There are many important material like oil harden non shrinkage steel left to be worked by CNC wire cut machine.

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